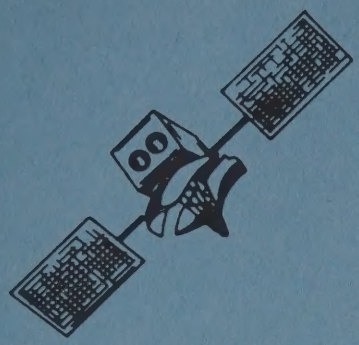
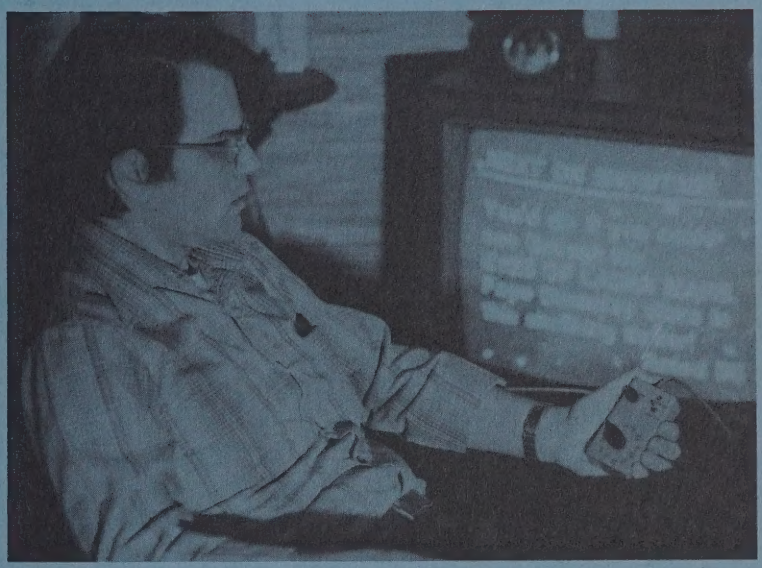
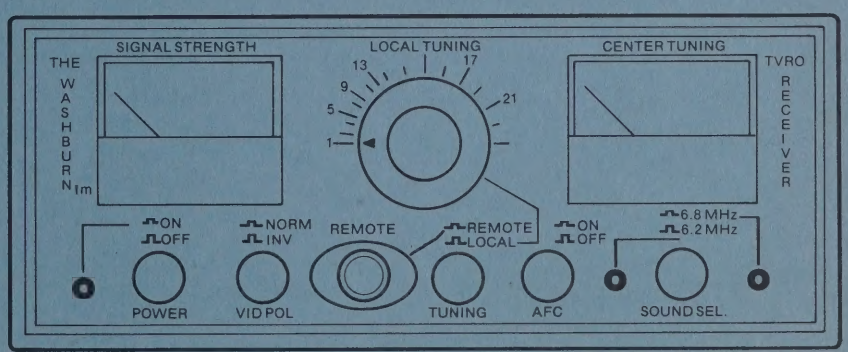


# THE WASHBURN TVRO RECEIVER MANUAL



**A complete construction manual** for a high performance 24 channel tuneable remote- tuned TVRO receiver and receiving control system for 3.7 to 4.2 GHz.




DEMODULATOR CONSOLE
Front Panel

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Satellite Television Technology
P. O. Box 2476
Napa, CA 94558
and Clyde Washburn, Jr.

**PRICE: $40 per copy**

# THE WASHBURN TVRO RECEIVER CONSTRUCTION MANUAL

**...an extremely thorough manual created by Clyde Washburn, Jr. and Satellite Television Technology to assist you in creating your own 'commercial quality' satellite TV reception terminal.**

**TOPIC MATTER** **PAGE NUMBER**

Introduction To The Washburn Receiver..... 2
What Size Antenna Do I Need?..... 4
How Much LNA Gain Do I Need?..... 9
Theory Of Receiver Operation
& General Notes On The Circuitry.....10
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A Source For Washburn Receiver Boards, Parts and Modules.....44

**THE COVER - Clyde Washburn, Jr. is a Principal Engineer with staff research and technology evaluation responsibilities for a diversified high-technology corporation. Clyde has had 12 years of experience in the analysis and design of circuitry for VLF through UHF communications equipment and in recent years has specialized in the design of frequency synthesizers, holding four patents on high performance PLL circuitry [with additional patents pending].**

This manual has been produced and is being distributed by Satellite Television Technology, P. O. Box 2476, Napa, California (94558). The price of this manual is $40 per copy and **this includes the expressed permission** of Clyde Washburn, Jr. and Satellite Television Technology for the buyer-user of this manual to duplicate a **single receiver** as described herein for the **private use** of the purchaser. Commercial manufacture of this receiver or any portion thereof is reserved to those individuals or firms who have obtained the written permission and licensing authority of Clyde Washburn, Jr. **Duplication** of the circuit boards detailed in this manual for other than your own use on a one-board-set per manual purchaser basis **is prohibited**; circuit boards plus parts kits or alternately wired and tested receiver modules or complete receivers are available through licensee's of Clyde Washburn, Jr.; one source for such boards and parts is detailed in the rear of this manual.

**Copying This Manual - This manual is copyrighted 1980 by Clyde Washburn, Jr. and by Satellite Television Technology; © 1980.** This means that you are **not** allowed to copy the contents either for fun or profit utilizing any means available to your creative mind including but certainly not limited to rushing to the office copying machine and zipping off one or several dozen copies for your free-loading friends who are too cheap to invest $40 in their own Washburn Receiver Manual. This manual is so complete and so thorough that the game plan is intact here for virtually anybody with a few thousand extra dollars kicking around and a garage workshop to enter the home TVRO receiver business. **This too we must advise you against doing** since only those individuals or firms that have negotiated a 'license' with Clyde Washburn, Jr. are authorized to produce either the full Washburn Receiver or portions thereof for commercial distribution and one assumes profit. Author-designer Washburn has labored long and hard on the receiver that is described herein and the original manuscript from which this exhaustive manual has been prepared. As the creator of an 'original work' he is entitled under U.S. statutes to realize the benefits of his labor without being ripped off by those who are either too lazy or too cheap to invest their own time and money into developing their own (commercial) TVRO receiver. If you have a serious interest in entering the TVRO receiver field, either as a manufacturer or distributor of hardware, STT encourages you to play the game straight and enter into proper negotiations with Washburn for his licensed-permission to exploit his handiwork. To those who have purchased this manual with no intent other than to finally get down to work assembling your own private-use satellite television earth receiving terminal, we wish you the best of success in what will probably turn out to be the most exciting project you have or ever will find yourself engaged in!

**CONTACTING STT:** For additional copies of this manual ($40 per copy) or for additional information concerning several other home-construction TVRO manuals offered by Satellite Television Technology (or the monthly **Satellite Digest** publication and a large library of videotapes), you may contact the STT editorial office as follows: **Satellite Television Technology, P. O. Box G, Arcadia, Oklahoma 73007** (405-396-2574). The Napa, California address shown elsewhere is primarily for shipment of manuals and other STT literature and no day to day customer contact is carried on via telephone from that office.

## INTRODUCTION

The Washburn TVRO receiver is an evolutionary update of the Howard Terminal receiver and was conceived to provide a unit that operates as virtually a consumer appliance with the following significant operational features:

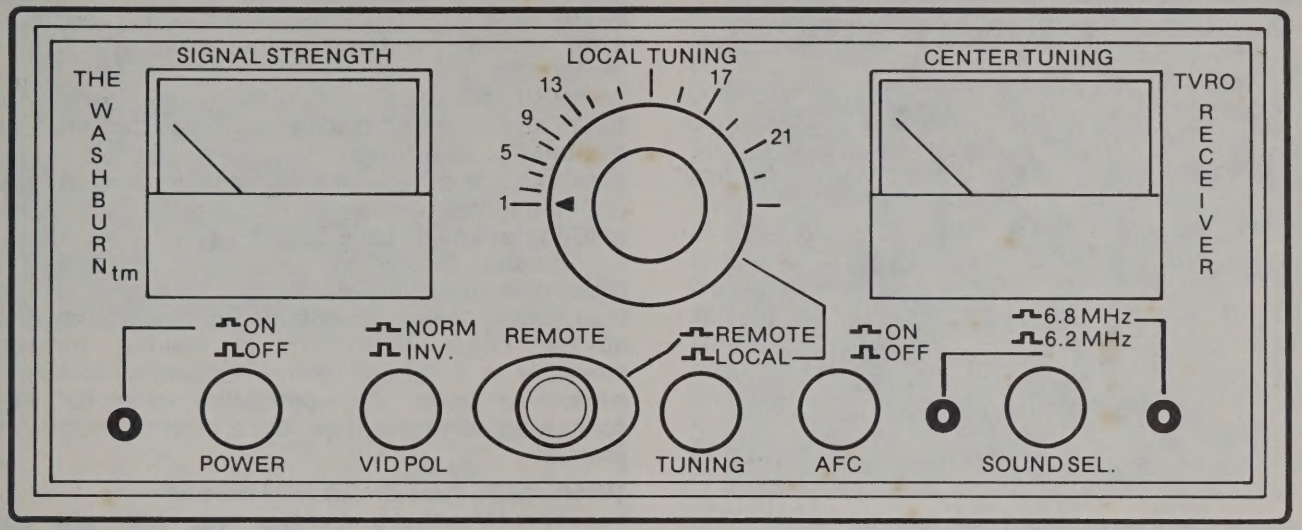
1) **Distributed construction**...utilizing an out-of-the-way downconverter (mounting separate from the demodulator proper) with an LNA power supply, a feed rotation system (to allow operational remote control of the feed point antenna for separate reception of vertically and horizontally polarized transponders), a small demodulator console with full provisions for constant monitoring of the system performance, and, a hand-held remote control that allows the viewer to adjust the system to each of the 24 channels found on SATCOM birds (or alternately 12 on ANIK, WESTAR birds) with a remote volume control. This design allows operation by a non-technical viewer without the requirement for special instructions (**See figures 1 to 5.**)
2) **Extended Threshold**...a state of the art approach to threshold extension that allows sparklie-free reception of program material with CNRs of 8 dB and above, achieved with-**out** compromises in IF bandwidth, video bandwidth and with special design attention to maintaining video phase and amplitude linearity as one would expect to find in a high dollar commercial receiver package.
3) **Low distortion audio**...a unique approach to recovering **all** of the audio bandwidth present on the satellite transmission utilizing a true low-distortion, low-noise, high-fidelity audio output with remote volume control and **automatic selection** of either the 6.2 or 6.8 MHz sound subcarriers; with indicators to show which audio subcarriers are present and a priority selection system so that the presence of some other modulation format (such as slow scan video) on 6.2 MHz will not be selected for listening (but a **normal** audio modulated subcarrier on 6.2 MHz on a different transponder **will** be heard). Additionally, CCITT (or ANIK) subcarrier frequencies different from the normal 6.2 and 6.8 MHz North American DOMSAT birds can also be received and de-emphasis supplied by component value changes.
4) **An AFT that works**...as well as the RCA home receiver Colortrak® system and provides a very high overall level of dispersion cancellation, eliminating any need for a complex and expensive frequency synthesis system.
5) **VTR compatible inputs and outputs**...to provide easy back-feeding of a home (or neighborhood) MATV system, plus simple off-bird-recording without additional switching or complex cabling.
6) **Careful component selection**...with attention to balancing costs, performance, reliability, ease of alignment and parts availability.
7) **Automatic and precise**...feed rotation control using a readily available, modest-in-cost (TV) antenna rotor assembly.
8) **Readily available boards and parts kits**... recognizing that many satellite TV enthusiasts have been hampered in their efforts to construct or acquire their own home satellite terminal by the general shortage of specialized component parts required for many receiver designs, and an even more acute shortage of circuit boards for receiver construction by non-design-engineers, every portion of this receiver is backed up by component parts sourcing **and circuit boards**. Additionally, the user of this manual will find circuit board layouts in this manual with which he may duplicate his own boards if he so wishes.

## MODIFIED FOR DUPLICATION

This receiver was originally intended as a 'one-of-a-kind' system created for private phase-lock detector research and for the personal use of Clyde Washburn. The receiver described here in schematic form and with accompanying parts layout drawings is the **latest version** of an original design that has been thoroughly de-bugged, trouble-shot and improved. Some photos of circuit boards are of the original (although modified) receiver system. Where there appears to be

Prototype front panel of the Washburn Receiver

Prototype rear panel of the Washburn Receiver



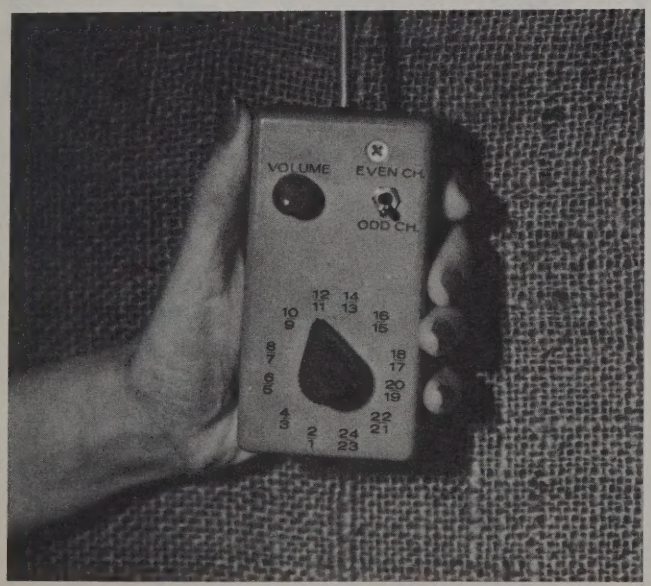

**DEMODULATOR CONSOLE**
**Front Panel**

**Kit/production version of Washburn Receiver [front panel]**

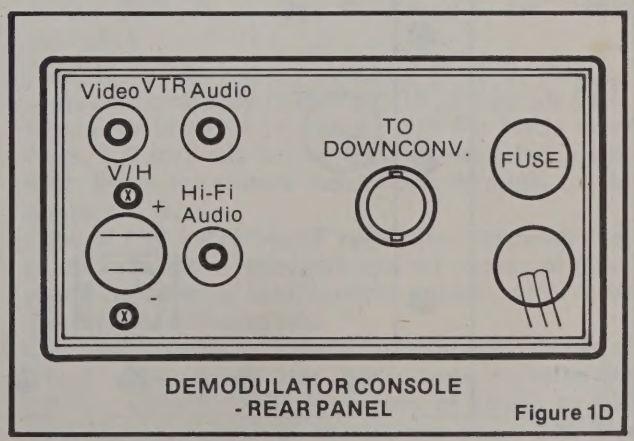
variance between the photos and the schematics or component layouts, the photos should be considered as illustrations of the original package while the schematics and component layouts should be treated as your 'manual' for duplication.

As with any high technology (state-of-the-art) design, and this is especially true in the fast changing world of microwave circuits, some parts called for are not found in your local radio shop or emporium. The simple truth is that with the possible exception of mass produced radar detectors for automobile use (operating in the 10.5 GHz range), and MDS downconverters (operating in the 2.1 GHz range) the mass production or consumer oriented microwave market is just not here yet. And because many microwave parts tend to be frequency-range-designed (on purpose for peak performance) even those parts generally available because of the radar detector or MDS fields will often as not fail to perform properly (if at all) in the frequency band of interest to us; 3.7 to 4.2 GHz.

Before the decision was made to distribute this technical manual by Satellite Televsion Technology, a firm commitment was obtained from an established electronic kit and circuit board supplier to insure that purchasers of this manual would be able to obtain the parts and boards they required to

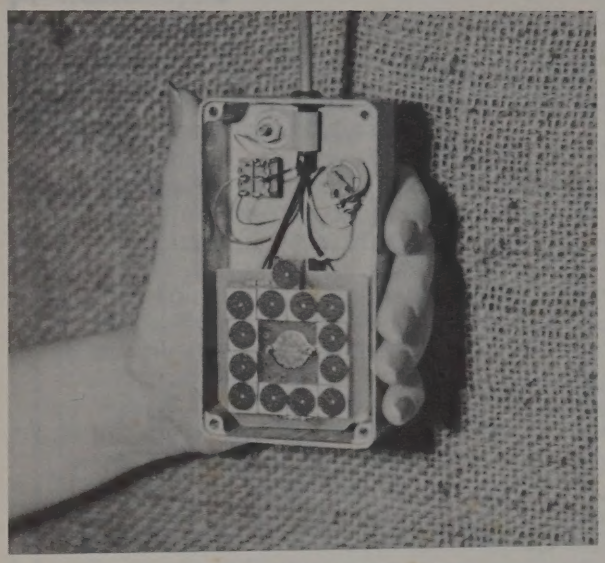



**Remote Control handheld unit [outside]**

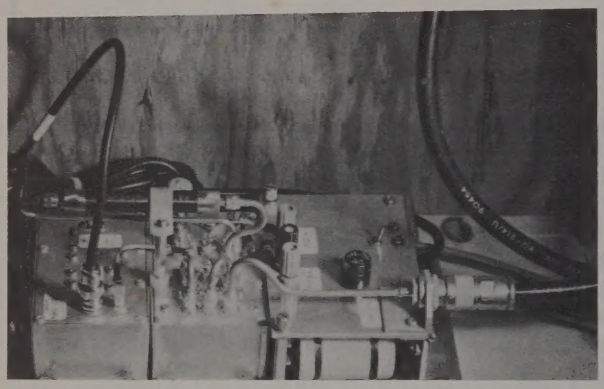



**DEMODULATOR CONSOLE - REAR PANEL**
Figure 1D

**Kit/production version Receiver [rear panel]**



**Remote Control handheld unit [inside**



**Downconverter prototype**

duplicate this innovative high performance receiver system. Users are therefore assured that the circuit boards, parts alone, parts plus boards or even wired and tested modules can be obtained at reasonable pricing from a supplier who is as anxious to see you get the parts you need as you are to get them! As additional parts sources become available or as alternate circuits are developed by Washburn or others for this receiver concept, you will find these 'updated reports' on a regular basis in (Coop's) **SATELLITE DIGEST** (1,2).

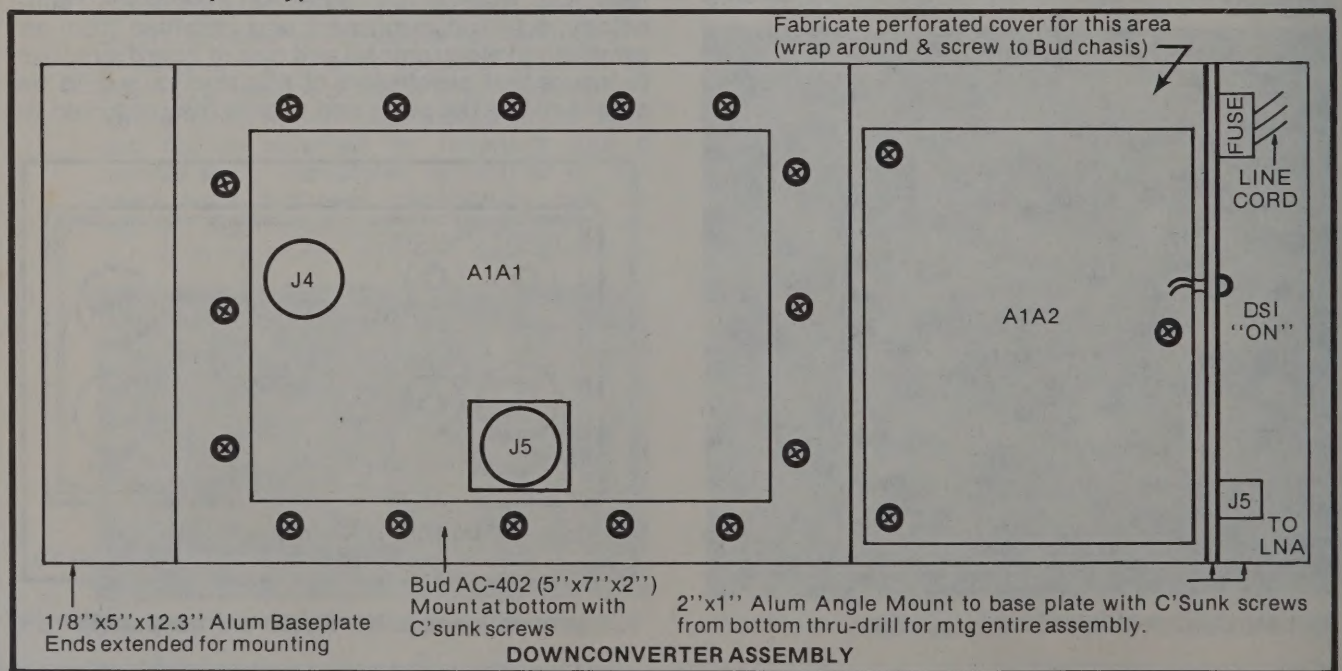
Finally, for those would be builders of this receiver who would feel more comfortable having the receiver designer available for consultation and advice, Clyde Washburn is making himself available on a flat-fee (one-time, paid in advance) consulting basis. An application form for this consulting service will be found in the back of this manual.

**WHAT SIZE ANTENNA DO I NEED?**

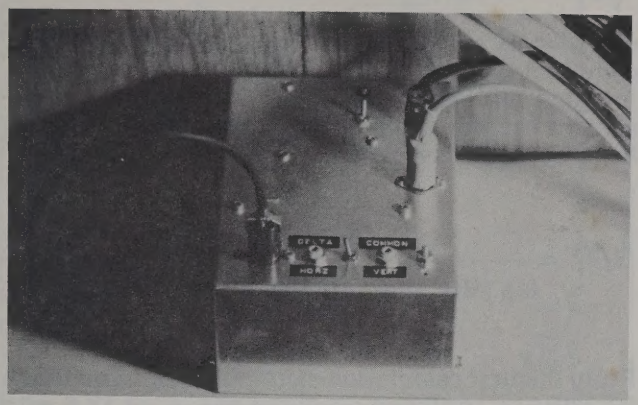
The Washburn receiver was originally designed for use with a 10 foot (39.3 dBi gain) antenna and a 120 degree Kelvin (K) LNA in a location penalized by what must be characterized as a 'very low elevation/look angle'. At the time of the basic receiver design RCA F1 was purported to be placing a 36 dBw footprint into western New York. Based upon these known (or believed) figures it seemed like a good idea to design the complete system so that it would exhibit the same (commercial as in CATV) "3 dB excess carrier margin" established for cable systems by the FCC. The original calculation therefore looked like this:

**Bird EIRP-Path loss + Ant Gain = LNA input dBw**

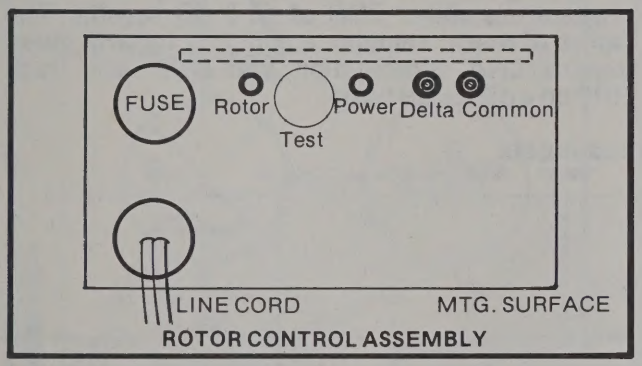
36 - 196.55 + 39.3 = -121.25dBw

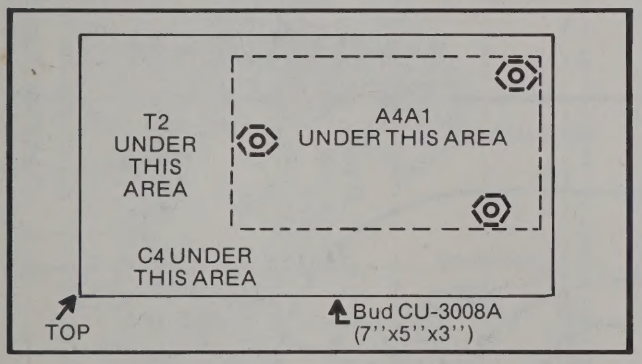



**DOWNCONVERTER ASSEMBLY**



**Rotor control assembly prototype**




**Rotor control assembly kit/production version**

To calculate the expected CNR (carrier to noise ratio):

(T° LNA + T° Ant) x Boltzman's Constant x I.F. Noise bandwidth = Equivalent LNA Input Noise in dB

$(120 + 50) \times 1.381 \times 10^{-23} \times 30 \times 10^{6} = -131.52$ dBw

**CNR = LNA input dBw - equivalent LNA input input noise in dBw**

CNR = (-) 121.25 - (-) 131.52

CNR = 10.30 dB

The original receiver design goal called for a 7.3 dB CNR **threshold** which correlated with the magnitude of improvement suggested in the 'theoretical' literature for an **optimum** PLL vs. a (frequency) discriminator circuit under similar conditions. The final system, described here, courtesy of the **actual** 34 dBw region EIRPs which SATCOM F1 is now known to have (versus the earlier RCA data on file with the FCC which 'promised a 36 dBw EIRP for the northeastern area of the United States), provides measured CNR levels of 7.4 to 9.1 dB across the various transponders (3). At CNRs of 8 dB and above sparklies have been observed only on saturated color bars and these sparklies are not apparent for normal program transmissions. Video SNR should be very close to or above 45 dB at the 8 dB CNR level. Studies by TASO (Television Allocations Study Organization) equate this type of video SNR to a rating of ''Excellent'' by 70% of the viewers (tested) and ''fine'' by 99.8% of the tested viewers. In ''eyeball terms'' this translates to ''some visible grain'', inferior by comparison to direct line of sight VHF-UHF reception (4) but ''viewable without annoyance or any sense of loss of detail''. If you are a very critical viewer and/or use a projection television receiver system you may risk some disappointment if the SNR delivered to your receiver is below the 51 dB video SNR routinely supplied by cable operators (5). A 51 dB SNR translates to a CNR of 14 dB and is TASO rated as ''Excellent'' by 95% of all tested viewers.

---

1) **Circuit boards, parts kits, wired and tested modules are available from: Mr. John Ramsey, Ramsey Electronics, P. O. Box 4072, Rochester, N.Y. 14610 [716-271-6487]**

2) **Coop's SATELLITE DIGEST is published monthly as the worldwide publication serving builders, designers, operators and sellers of low-cost [private] TVRO terminals. A subscription is $50 per year in U.S./Canada [$75 outside in U.S. funds], all copies are sent via first class mail. Write CSD, P. O. Box G, Arcadia, OK 73007 [U.S.A.]**

3) **RCA found during the summer of 1979, through tests conducted by COMPUCON, that their EIRP levels for both SATCOM FI and FII birds were from 1.5 to 3 dB** below **their anticipated levels with the most severe reductions throughout the eastern U.S.**

4) **Line of sight VHF-UHF reception assumes consumer standard receivers and no excess of man-made noise level interference present at or near the off-air receiving site.**

5) **Cable operators may in fact attain video SNRs of 51 dB** (or better) **at their TVRO receiving sites but seldom deliver SNRs in excess of 45 dB to any customers because of cumulative noise and distortion products inherent in any cascaded broadband VHF distribution system.**

If we are to look ahead to the eventual launch of SATCOM FIV and believe the pre-launch footprints supplied by RCA for their aborted attempt to launch FIII (which one assumes FIV shall replace), we can anticipate a range of EIRPs from 33.7 to 36.7 dBw across the major portions of North America (**see figure 6**). Similarly, if one is located where the present ANIK-B service is rated as 36 dBw or better (generally speaking north of the 40th north parallel), or is located where COMSTAR or WESTAR footprints are believed to be in the 34-37 dBw region (see **CSD** for December 1979), one might target 3 CNRs of interest as follows:

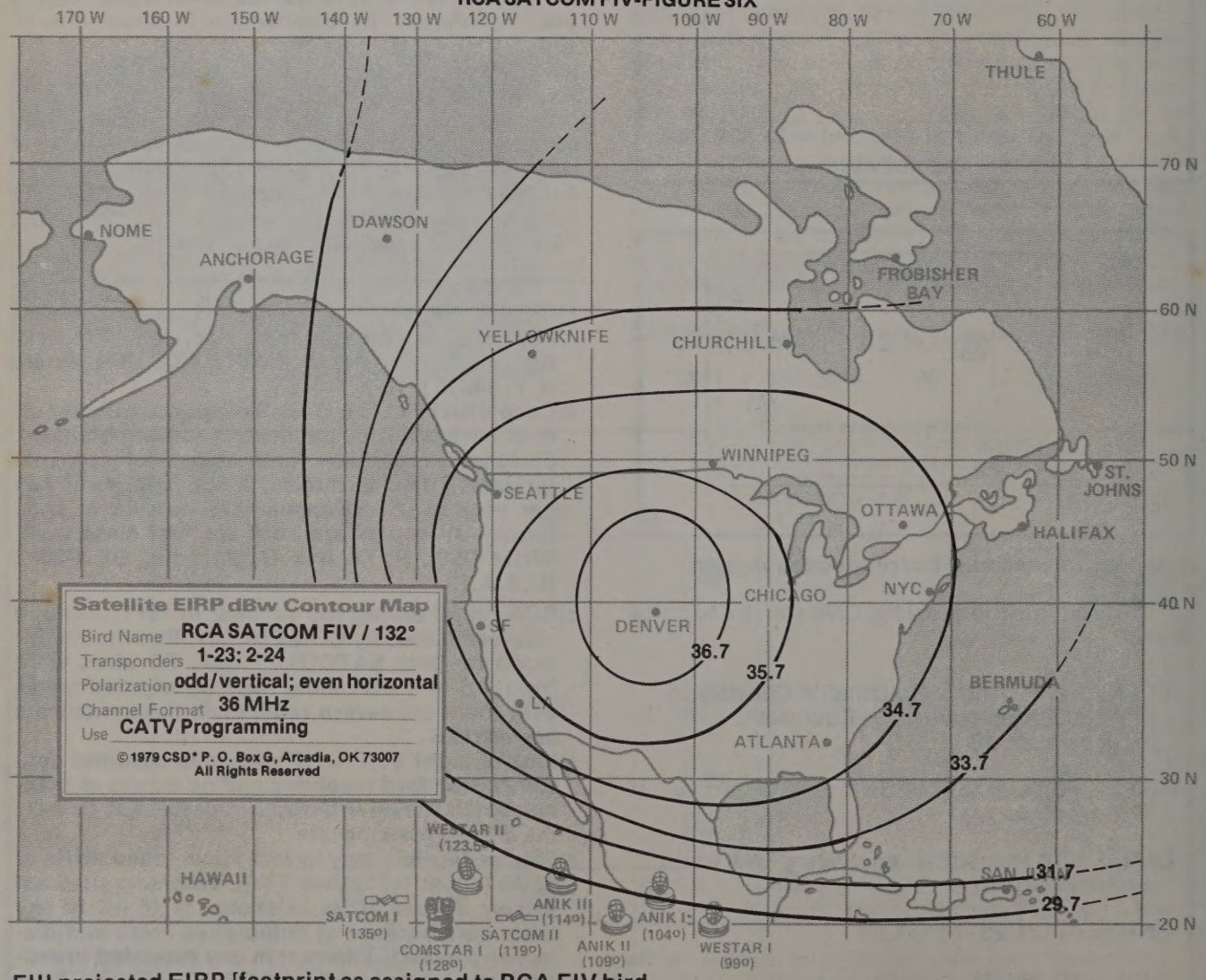
1) **8dB CNR** = marginal reception (at or just below threshold), lowest cost system
2) **11 dB CNR** = standard system margin (i.e. 3 dB built in for system 'aging')
3) **14 dB CNR** = highest quality picture (i.e. 51 dB SNR or better, 'studio quality')

Here the system figure of merit (or G/T°) is useful for evaluation of various antenna/LNA combinations. We are, afterall, determined to produce the best possible picture(s) within some constraints of budget, antenna-space-available and neighborhood aesthetics.

$$G/T^\circ = \frac{\text{Antenna Gain}}{\log(\text{effective antenna} + \text{LNA temperature})}$$

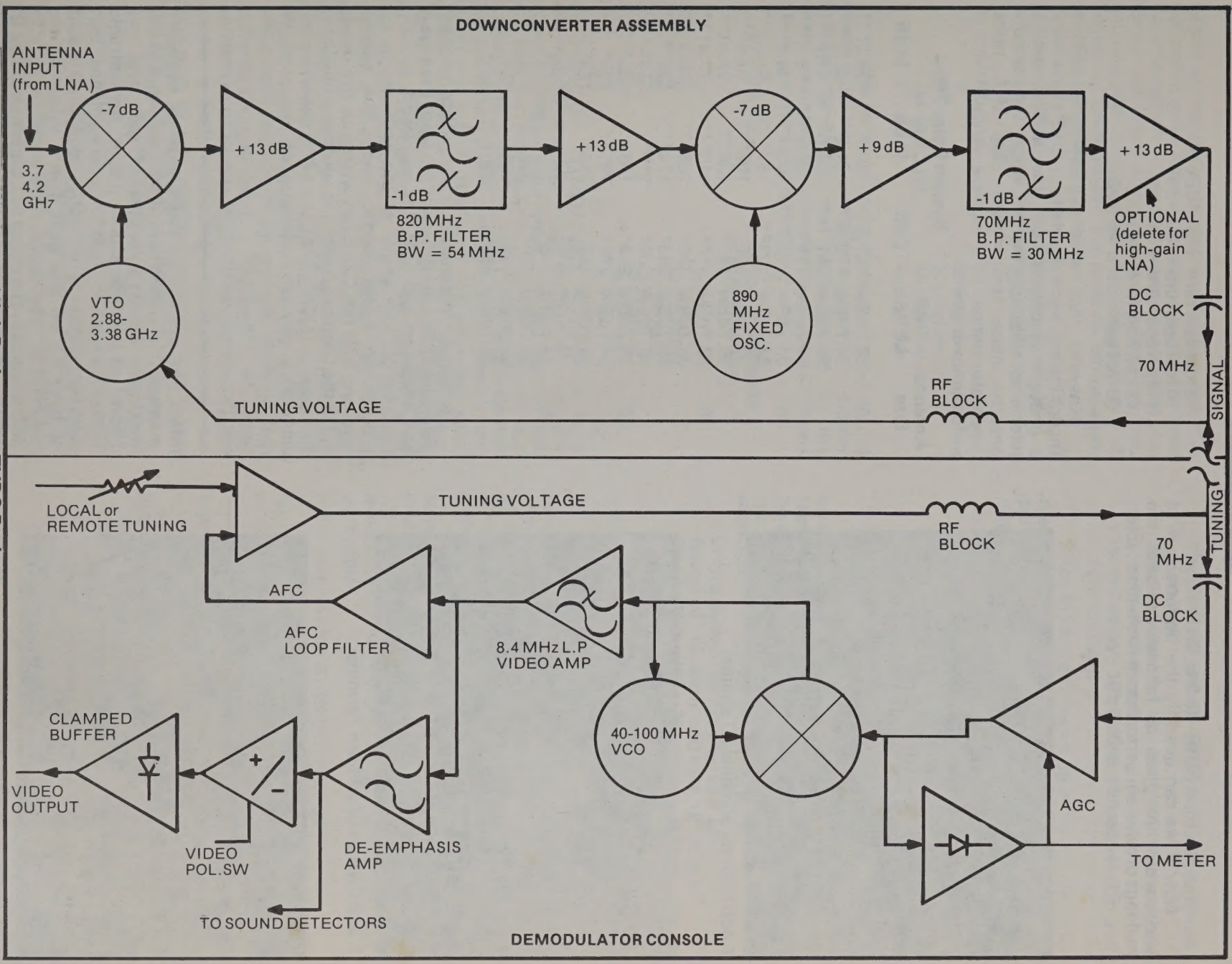
From the first calculation example we can see that a 39.3 dB(i) (7) antenna produces a G/T° of 17.6 with a 170 degree (T°LNA + T° Ant) system noise temperature and a CNR of 10.3 dB results. The 'figure of merit' remains a constant for any given antenna/LNA combination and CNR will track EIRP on a dB for dB basis.

**RCA SATCOM FIV-FIGURE SIX**




**FIII projected EIRP [footprint as assigned to RCA FIV bird**

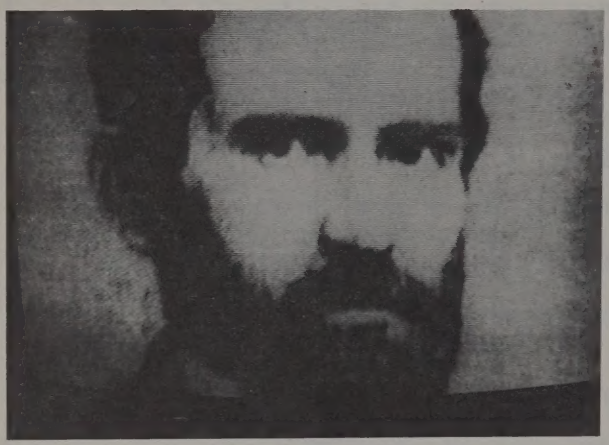
Block diagram of the Washburn High Performance TVRO Reciver



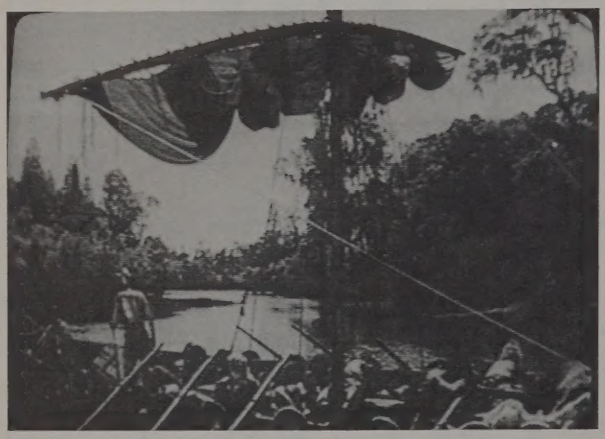
Thus: G/T° + EIRP - 43.3 = CNR

Now if we can quantify the performance of various antenna sizes as follows we have the makings of a system performance evaluation table:

6 foot aperture = 35.0 dBi
8 foot aperture = 37.5 dBi
10 foot aperture = 39.5 dBi
12 foot aperture = 41.0 dBi
15 foot aperture = 43.0 dBi
20 foot aperture = 45.6 dBi



**7.4dB CNR on Washburn Terminal**



**8.0dB CNR on Washburn Terminal**

**9.0dB CNR on Washburn Terminal**

Knowing then what our antenna gain is (thought to be), knowing what our EIRP signal level is (thought to be), we can then mathematically determine what our system noise temperature (antenna noise temperature **plus** LNA noise temperature) must be to achieve various levels of performance or service.

| Antenna Size | EIRP LEVEL | System Noise Temp for CNRs of 8 dB | 11 dB | 14 dB |
|---|---|---|---|---|
| 6' | 33.7dBw | 57.5°** | 40.7°** | 28.8°** |
| | 34.7dBw | 72.4°** | 51.2°** | 35.5°** |
| | 35.7dBw | 91.1°** | 64.5°** | 44.7°** |
| | 36.7dBw | 115°** | 81.2°** | 56.3°** |
| 8' | 33.7dBw | 97.7°** | 69.1°** | 48.8°** |
| | 34.7dBw | 123°* | 87°** | 61.5°** |
| | 35.7dBw | 155° | 109°** | 77.4°** |
| | 36.7dBw | 195° | 138°* | 97.5°** |
| 10' | 33.7dBw | 155° | 110°** | 77.4°** |
| | 34.7dBw | 195° | 138°* | 97.4°** |
| | 35.7dBw | 246° | 174° | 123°* |
| | 36.7dBw | 309° | 219° | 154° |
| 12' | 33.7dBw | 219° | 155° | 109°** |
| | 34.7dBw | 276° | 195° | 137° |
| | 35.7dBw | 347° | 246° | 173° |
| | 36.7dBw | 437° | 309° | 217° |
| 15' | 33.7dBw | 345° | 245° | 173° |
| | 34.7dBw | 434° | 308° | 218° |
| | 35.7dBw | 547° | 388° | 274° |
| | 36.7dBw | 688° | 489° | 345° |

Antenna temperature is a function of many factors including the design of the feed, the **type** of feed employed and how it is employed, and the elevation or 'look angle' of the antenna. In the mid-Atlantic states north along the eastern seaboard into the Canadian Maritime Provinces, and in the Caribbean east and southeast of Miami, the location of RCA's F1 satellite (135 degrees west) produces a very low 'elevation' or look angle for your antenna. As the antenna comes closer and closer to the horizon (i.e. ground) to the west/southwest to boresight upon F1 the antenna

---

7) **Most [but not all] parabolic antenna suppliers measure the forward gain of their antennas in the maximum lobe as a function of 'gain over and above' an isotropic source** (i.e. i). **An isotropic source is a mathematical 'reference antenna' that does not exist in the real world; generally it is said to have 2.1 dB** less gain **than a simple dipole mounted in 'free' space. References here are in dBi; antennas referenced to a dipole would be in dBd** (d indicating gain above a reference dipole in free space).

begins to 'see' the earth itself as a noise source. It is not possible to accurately stipulate the antenna noise temperature for **all antennas** of a specific size for **all locations** but for a common prime focus fed antenna with a look or elevation angle in the 12 degree or lower region the antenna temperature may be approximated as follows:

| Antenna Size | Antenna Temperature (degrees Kelvin). |
|---|---|
| 6' | 70 degrees |
| 8' | 58 degrees |
| 10' | 50 degrees |
| 12' | 44 degrees |
| 15' | 40 degrees |

In the midwest and further west (and south) where the elevation/look angle rises simply because the bird is now higher in the sky the antenna temperatures under the above conditions can be approximated as follows:

| Antenna Size | Antenna Temperature (degrees Kelvin) |
|---|---|
| 6' | 36 degrees |
| 8' | 32 degrees |
| 10' | 29 degrees |
| 12' | 26 degrees |
| 15' | 24 degrees |

Since our system noise temperature is a composite of the LNA noise temperature **and** the antenna noise temperature and we can now see that our antenna contribution is largely beyond our control (having been determined by where we live and the antenna size chosen plus to some small extent the type of feed with the antenna), what about the contribution of the LNA? It would appear that the minimum practical LNA temperature (or noise temperature/factor if you identify with this nomenclature) is in the 85 degree K(elvin) region for the immediate future; and this is available only at a staggering cost (8). We can therefore, in our composite table of antenna sizes vs EIRP levels, eliminate any case where the required **total system temperature** is unattainable in the (north)eastern United States (and the far southeast such as Florida, the Caribbean, Bermuda and the northeastern portions of Canada)...indicated by a **single asterisk** (*), or, throughout the same area as well **plus** the midwest, south and southwest...indicated by a **double asterisk** (**).

Clearly the 6 foot size parabolic antenna is unworkable virtually anywhere for a serious viewing system (9). If an absolute minimum size antenna is important (because of neighborhood restrictions, lot size problems, etc.) and cost of the total system is no object (i.e. you are prepared to spend whatever is required for the LNA), the three identified levels of performance could be obtained as follows (**with an 85 degree K LNA**):

**Marginal** - 8', except 10' in the south and New England
**Standard Quality** - 10', except 12' in the south and New England
**High Quality** - 12', except 15' in the south and New England

Since the current 'sweet spot' for cost/performance in commercial LNAs is at the 120 degree K point, an optimum cost fully purchased system might be (**with a 120 degree K LNA**):

**Marginal** - 8' midwest, 12' south and New England, 10' elsewhere
**Standard Quality** - 10' midwest, 15' south and New England, 12' elsewhere
**High Quality** - 12' midwest, 20' south and New England, 15' elsewhere

If you have acquired this manual with the serious intent of constructing your own TVRO terminal electronics (including the LNA) you might be wondering what you can expect with a bi-polar type (HXTR 6101) LNA of your own construction married to the receiver described here:

With a homebrew **275 degree** K LNA...
**Marginal** - 15' south and east, 12' others
**Standard Quality** - 20' south and east, 15 foot elsewhere
**High Quality** - 15' in midwest only around boresight (see figure 6), 20 foot elsewhere except south and east; not practical there.

Those considering use of the Swan Spherical or other sizes of antennas can readily make the same comparisons by appropriately substituting the gain of the proposed antenna and the effective noise temperature of the antenna in the above calculations. (10)

At this point one can determine the best trade off(s) in cost, performance and mechanical problems associated with antenna size (mounting, foundations, wind loading, etc.) and reach some logical conclusions about how your own system will go together.

**HOW MUCH LNA GAIN DO I NEED?**

The Washburn TVRO Receiver provides a fairly typical noise figure of 13 dB. What does this mean? Simply that an input signal will have added

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8) **While prices change rapidly in the commercial LNA field, an 85 degree 'guaranteed' LNA is typically in excess of $5,500.**

9) **An exception might be reception from Canada's ANIK-B on 4 GHz in central Canada where an EIRP of 38 to 39 dBw is quoted by Telesat Canada.**

10) **The real-world noise temperature of a Swan Spherical TVRO Antenna is a subject for some debate at the present time. It is probably higher than an equivalent sized parabolic for** low **look angles.**

to it noise at a level 13 dB above thermal (which is usually assumed to be 290 degrees Kelvin), or 5800 degrees K. Note however that at the same point the effective noise temperature of the antenna will have been **amplified** by the LNA gain, minus feedline (LNA to receiver) losses. In a complete system, therefore, the 'true' antenna noise temperature is actually:

$$T°Overall = T°LNA + T°Ant + \left(\frac{T° \text{ Receiver}}{\log\text{-}1(\text{G-LNA} + \text{Feedline loss})}\right)$$

Clearly, since LNA temperature reduction below the 'sweet point' is so expensive and bulk LNA gain less so, it would be imprudent to allow the receiver to add more than perhaps 5% (preferably 1%) to the overall system temperature. With the assumptions of the standard margin (11 dB CNR where 8 dB CNR is considered to be the FM threshold for visible sparklie noise) and an eastern or southern location (where one wants to give up little in system temperature because of antenna noise contributions which cannot be avoided with smaller sized antennas), the minimum net gain from antenna input to receiver input for typical LNA noise temperatures would be:

| LNA T° | 5% Overall Degradation | 1% Degradation |
|---|---|---|
| 85 | 29.3 dB Gain | 36.3 dB Gain |
| 100 | 29.1 dB Gain | 36.1 dB Gain |
| 120 | 28.5 dB Gain | 34.1 dB Gain |
| 180 | 27.1 dB Gain | 34.1 dB Gain |
| 275 | 25.7 dB Gain | 32.7 dB Gain |

If you select a standard **commercial** LNA with **50 dB plus of gain** (55 dBg typical) you will be in an overkill situation for nearly any feedline and should seriously consider either RG-214 at -23.5 dB per 100 feet (therefore with a commercial LNA good for up to approximately 80 foot runs) or for short runs RG-223 at -43.5 dB per 100 feet (therefore useable for a run to approximately 40'). Why throw dBs away? Because excess gain will do you no good and may even require a receiver input pad with the higher EIRPs and larger antennas (see Downconverter Theory and Operation, in this manual).

"Designed for private" and home-brew LNAs should be chosen to allow a minimum of 25 to 30 dB gain (dBg); with noise temperatures of 275 to 85 degrees K respectively, at the receiver input, both for the overall noise considerations discussed here and to insure adequate signal to the video detector in the receiver proper.

## GENERAL NOTES ON CIRCUITRY

Whereever possible the least expensive type of component part that will produce the receiver performance which the design is capable of is indicated. Substitution of lesser grade components should be done with some trepidation, especially in these areas:

**Resistors:** Film resistors are indicated where their stability with time and humidity are warranted. They could be used throughout **with a few exceptions** but are recommended only where indicated. Tight tolerance (1% and 2%) resistors are specified in places where their use would avoid the need for additional pots and subsequent alignment or user adjustments. If you find some of these values difficult to obtain we suggest that you carefully select these resistors from 5% film units utilizing an ohmeter of sufficient accuracy.

**Capacitors:** Capacitors should be the same size, type and temperature characteristic noted on the parts list. Substitution of sizes will cause difficulties in getting the parts onto the PC boards as depicted here.

**Transistors:** Do **not** substitute "replacement type" transistors for those specified unless you are **certain** they do, in fact, use the same die type and have equal or better specs for the standard type specified.

**Diodes:** Controlled conductance diodes are specified where **forward** characteristics are important. Again, if hard to find they may be selected as follows:

1N4152: 1N4454 or 1N3064 selected for Vf **between** 590 and 670 mV at 1 mA.

1N4448: 1N4148 or 1N914 selected for Vf **less than** 1.0 V at 100 mA.

**IC's:** The Plessey SL1600 series MECL III devices should **not** be substituted unless you have Plessey devices available for comparison since proper operation depends upon a particular internal resistor value and capacities that are not depicted by the data sheet and may vary substantially from one vendor to another.

**Pots:** Allen-Bradley panel pots are specified where their smooth electrical operation is desirable. Check other brands for this quality before substituting and avoid 'TV Replacement' type open pots with the exposed elements, as the DC current readily pits these in a short time causing very erratic resistance change with rotation.

**Line Cords:** Two-wire line cords are specified since it is **assumed** that a fully and properly grounded antenna is in use, and that the receiver input from the LNA is grounded to the building grounding system at the point of entry. **With** these conditions use of a three-wire line cord will promote ground loops that can cause unwanted 60 Hz oscillator modulation.

**Hardware:** Screws, clamps, spacers,etc. that are reasonably obvious have not been specified.

**Overseas Use:** 230 V 50/60 Hz power supply

components have been identified in all cases; be sure the input line **really is** 115 or 230 VAC, + /-10%, and correct or regulate to these values as necessary.

**DOWNCONVERTER SUBASSEMBLY A1A1**

References:
Schematic - see figure 7
Parts list - see table 1
PC artwork - see figure 8
PC assembly drawing - see figure 9

**Theory of Operation**

The input signal from the LNA, comprising a band from 3.7 to 4.2 GHz is applied to the first mixer U1 which receives its LO from VTO-U3[*] in the range 2.88 to 3.38 GHZ, resulting in a first I.F. (frequency) of 820 MHz. This frequency was chosen so that a second conversion oscillator, operating at 890 MHz, produces no harmonics which lie either in the primary 3.7 to 4.2 GHz band or in the 2.06 to 2.56 GHz image band.The 820 MHz I.F. is sufficiently high to produce a low image frequency readily attenuated by the LNA, and allowing a simple image filter made from surplus RG-49/U waveguide to be used between the LNA and the receiver **in the unusual case** where more image rejection is required (with a prime focus feed no significant attenuation of the image would result from the LNA waveguide **unless** a **very high** I.F. was used). A variable first I.F. (such as 500 to 1000 MHz) is not used for two reasons:

1)A variable I.F. would require a tracking filter, wide compared to the signal (greater than 30 MHz), and maintaining uniform amplitude response and phase delay as it is tuned over an octave bandwidth. If a cable-quality signal is the objective these constraints are too severe to be met by 'converted TV tuners'.

2)The possibility of having two tuner-type devices operating simultaneously is at best less

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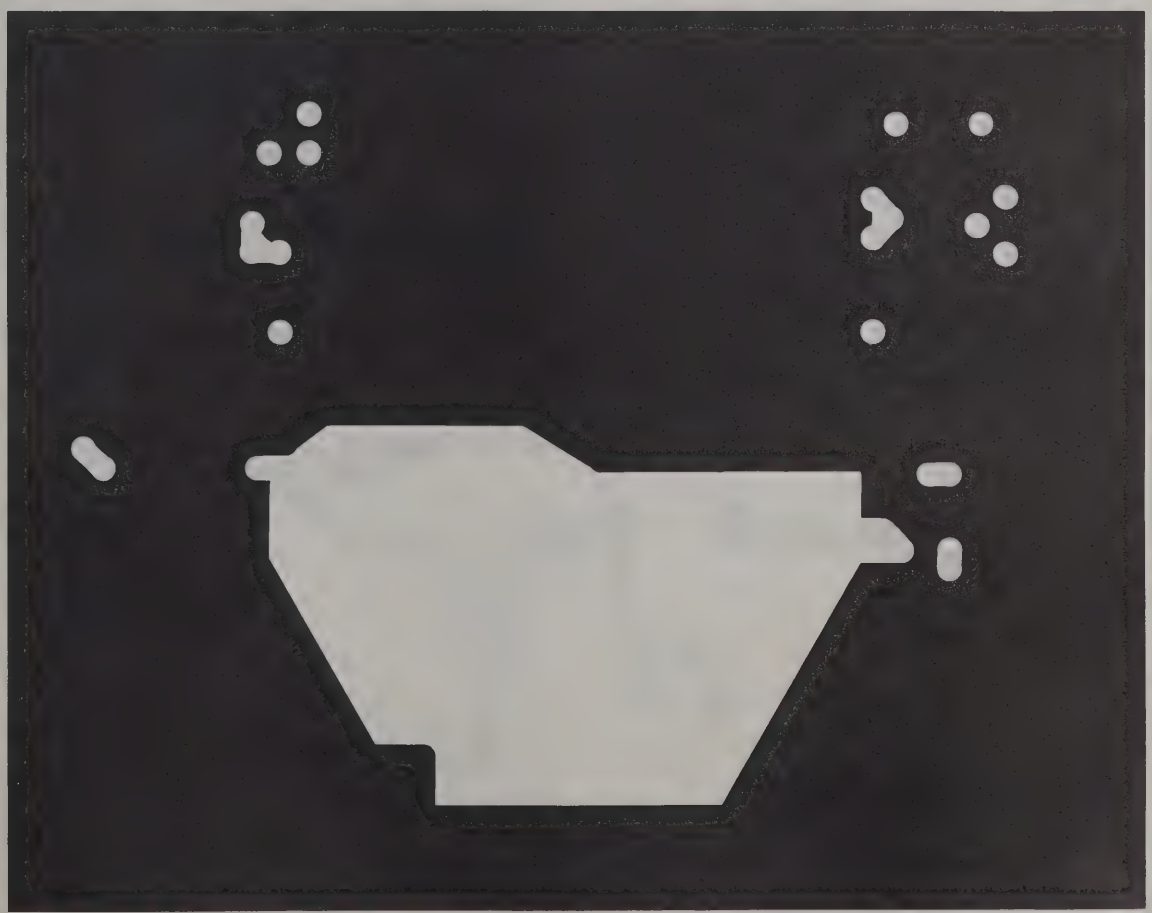
***-A Watkins-Johnson VTO is used rather than the more common Avantek unit to avoid limiting the receiver noise floor. Avantek claims** (per their data sheet and subsequently confirmed by a telephone call) **no better than a -60 dB/1 kHz noise floor which would impose a receiver CNR limit of approximately 15 dB which would in turn degrade an input CNR of 15 dB to 12, or 10** (good quality), **or 8.8** (marginal). **They may be typically somewhat better, but it is the opinion of designer Washburn that for the same money the W-J at greater than -100 dBc/1 kHz or greater than -25 dB dBc/30 MHz is a safer buy.**



intriguing than it first appears when you consider that:

a) You will have potential problems with the LO or its harmonics of one tuner being on the signal or I.F. (frequency) of another transponder;

b) Since ortho-polarization (i.e. alternating between vertical and horizontal transponders) is used by the satellites of major interest, you would still be limited to transponders from the same vertical or horizontal group. If you are well enough heeled to install an ortho-coupler feed and a pair of LNAs, two separate receivers are clearly not a major additional expense item and the auto-control of LNA rotation used in this receiver design can be easily converted to switching coaxial relays to put you on the appropriate LNA output. A tuner-type system would require duplicate down converters also, giving it no clear advantage for a full-bore watch one/record one system.

820 MHz has the additional advantage of being at the 'sweet spot' of input and output VSWR of the readily available GPA 1002 TO-5 amplifier modules. The signal coming from the first mixer U1 is amplified by U2 before application to 1st I.F. filter FL1, accomplishing two objectives; starting to establish receiver noise figure by providing significant gain and buffering (reducing) the output VSWR variation of mixer U1, so that the filter has a known and constant source impedance to work with. Note that U2 has an input signal of 12 simultaneous channels providing ample opportunity for cross modulation. Keep the receiver input signal (voltage) **below** the specified level (using an external attenuator if necessary, or excessive coax which acts as an attenuator) to insure cable quality (-57 dB) crossmod. Amplifier substitutions is not recommended; units having a lower 3rd order intercept may crossmod and units having higher gain may cause crossmod in U4 or later stages.

The output of the 1st I.F. U2 is applied to the 820 MHz I.F. filter, FL1, whose most important characteristic is **not** its 54 MHz 3 dB bandwidth but rather the center (more or less) 43 MHz which exhibits less than 1/2 dB insertion loss change, low VSWR and flat phase delay. This allows the second conversion oscillator to drift +/-6.5 MHz with virtually no ill effects on signal quality. The adjacent channels are rejected by approximately 9 dB with approximately 30 dB rejection of the next adjacents and approximately 45 dB rejection of the

third removed adjacents. Image rejection (at 960 MHz) is typically 60 dB and approximately 30 dB of additional 890 MHz oscillator rejection is provided to discourage high-order spurious generation in U1 or U2.

The output of FL1 is buffered by U4, another GPD-1002, which again provides some constancy in terminating impedance and completes definition of the receiver noise figure by providing significant gain. Remember that we are still carrying a three-channel 'field' (the desired transponder plus the outside pair at approximately - 9 dB) so too much gain would create a crossmod hazard.

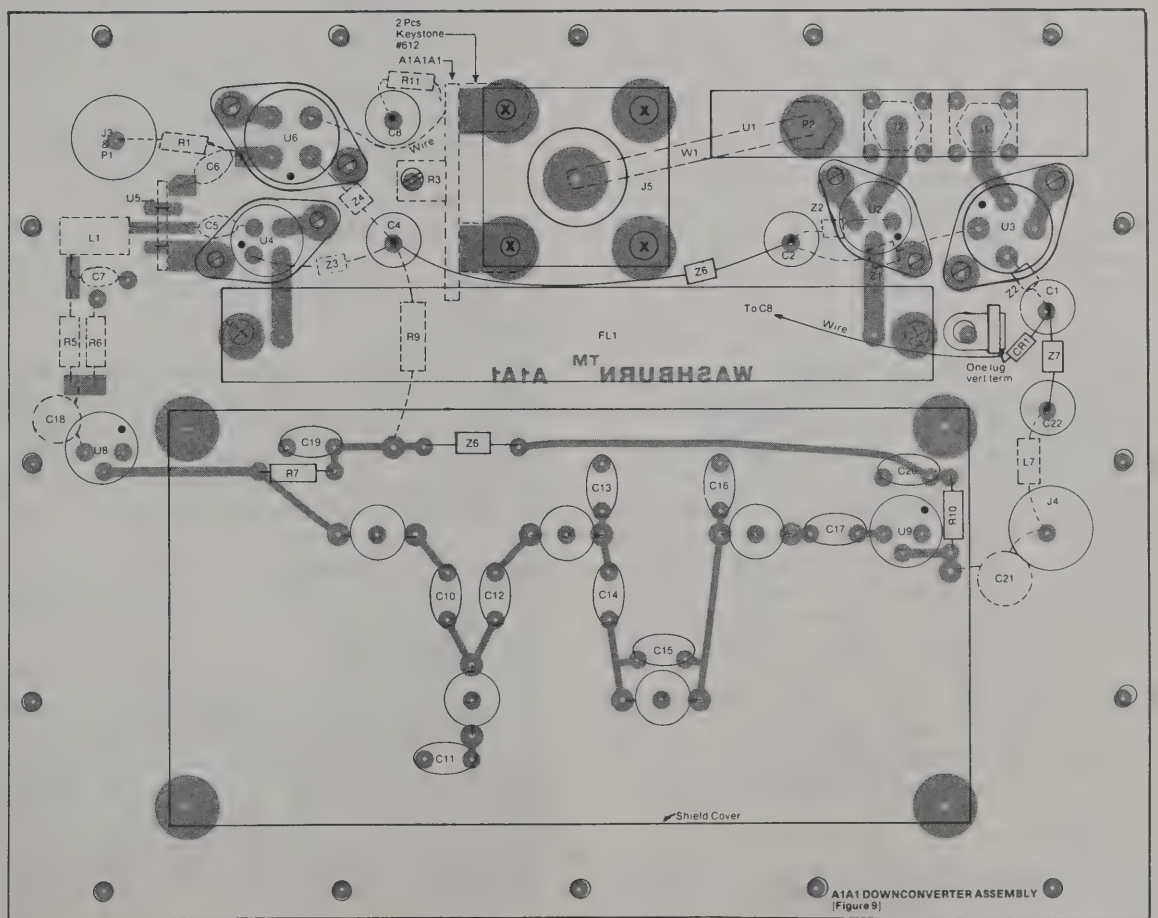
Mixer U5 converts the 820 MHz I.F. to 70 MHz and receives its injection from VTO-U6, used as a fixed oscillator at 890 MHz. A free-running VTO was chosen over a crystal oscillator plus multiplier because, as noted previously, a few MHz of drift in the LO is easily accomodated, and the absence of subharmonics on the oscillator output assures spurious-free performance. In this case the Avantek VTO is quite adequate having a typical noise floor of approximately -72 dBc / 1 kHz which is approximately -27 dBc / 30 MHz; well in excess of the CNR range of interest (8 to 14 dB). Shunt regulator U7 stabilizes the tuning voltage to VTO-U6, with CR2 providing temperature compensation to cancel the strong negative TC of the oscillator frequency (the compensation can be somewhat imperfect as FL1 is adequately wide with no compensation whatsoever; however, AFC range would be used up and that would limit the ambient range over which the AFC will hold.).

A pad formed by R5 and R6 limits the input signal level to U6, again to maintain cable quality crossmod performance. Here a low-cost Motorola MWA 120 is used, with R7 correcting the output impedance to provide a 50 ohm source to the 70 MHz I.F. filter.

The I.F. filter is schematically identical to that used by Taylor Howard (see **Howard Terminal Manual** from **STT**); however it has been implemented with very inexpensive pre-wound plastic coils. It is ideal for the purpose of providing an **arithmetically symmetrical** passband (with accompanying phase symmetry), 1/2 dB P-P amplitude ripple and greater than 30 dB adjacent channel rejection. Note that anything greater than 30 dB is totally wasted since only 30 dB isolation is provided in the most ideal case **at the satellite** between ortho polarizations which becomes the limiting case when receiver adjacent channel rejection exceeds 30 dB.

Why a 30 MHz wide I.F. filter rather than 27 or 24 or 22 or 20 as has been variously suggested? A list of reasons runs like this:

1)**Carson's Rule** would make the width of the non-dispersed video signal 29.9 MHz if one



wants to recover **all** significant (sideband) information. Where dispersion cancelling AFC is used (as in this case) no additional bandwidth (BW) allowance is necessary.

2)**The concept** that threshold will **improve** for a **PLL** detector with bandwidths below Carson's Rule is not true when one concentrates on reduction of sparklies on saturated colors - the most annoying signal observation at threshold. This effect is second-cousin to a bit error in a digital FM system and for the type of PLL used here a small minima in bit error rate occurs **at** the Carson's Rule BW; with degradation in either direction (see Klapper and Frankle "**Phaselocked and Frequency Feedback Systems**", chapter 9).

3)For a relatively sharp cut-off filter, necessary for adequate adjacent channel rejection, only the **inner**most 60 or 70% will provide linear phase delay for a flat-topped amplitude response. For a 30 MHz bandwidth this 60-70% or 20 MHz 'sweet spot' correlates nicely with the spectrum used by the highest energy portion of the FM signal with $Sin^2$ window modulation (see **Steve Birkill** in **CATJ** for december 1978 or June 1979). If we narrow the filter the extreme phase change accompanying transition to the cut-off region will begin to occur in the high energy band of the signal.

Bandwidth reduction, then, would have the effect of lowering the threshold for **low level** modulated video (few if any saturated colors) while increasing the occurrence of sparklies on saturated colors, and eventually inducing color distortion due to nonlinear phase. **Note that all of this refers only to the detector used here** (with an extremely wide closed loop bandwidth). PLL detectors with closed loop bandwidths closer to the video bandwidth and/or second order response will behave quite differently and may very well benefit from bandwidth reduction. Since they also tend to produce sparklies at a higher CNR there is a net deficit when directly compared with the same G/T° (figure of merit) antenna/LNA combination.

The final stage of the downconverter, amplifier U9, **must be deleted** if a commercial LNA (50 to 60 dB of gain) is to be used in the system, to avoid overload and/or touchy gain adjustment in the following PLL/Demod section. Note that a lower dynamic range MWA 110 is used here since the adjacent channels have been removed by filtering and with them gone there is greatly reduced crossmod hazard. C21 (or C17 with U9 omitted) serves as a DC block at the I.F. output, J4, allowing the tuning voltage for VTO-U3 to be brought in via the same (RG-58) coax used to convey the I.F. signal to the Demod Console, A2.

**Construction Hints**

**U1 Installation:**

Temporarily mount J5 from the top of the PC board without the internal parts. Form a hairpin loop of .141 hardline to reach from the J5 centerline to U1-IC centerline. Install the internal parts for J5 on the hardline so that the threaded clamp is just above the end of the bend radius. The specified spacer-adapter is used as follows:

1)Cut through the copper and Teflon leaving .20'' of center conductor exposed.

2)Sweat the spacer on the copper jacket flush with the end of the jacket. The heat will cause the Teflon insulation to extrude outward approximately .045''. This should **not** be removed as this is the correct pre-trim for the center conductor insulation.

3)Temporarily install the J5 inner parts feeding the other end of the hardline hairpin up through the hole at U1-IC from the bottom. Slide P2 over the hardline from the top and mark coax so that this connected will have its mating surface as far above the board as J1/J2.Unscrew the internal parts of J5, then remove the body of J5 from the board.

4)Install P2 (pulling the hardline up through the board for room to work above) and scrape off any solder preventing the inner sleeve of P2 from fitting into the PC board hole. Screw P2, J1 and J2 on the correct **ports** of mixer U1 and lower it into place (J1 and J2 in **proper** board holes) Solder J1 and J2 flanges to the ground plane on the **two** outboard sides.

5)J5- body may now be permanently installed by screwing in the internal parts as the body is lowered in from the top. Secure with screws at the corners.

6)Should U1 (later) need to be removed ignition wrenches can be used to loosen the three connectors from the side (loosen equally to prevent stresses on the mixer).

**U3, U2, U4, U6 Installation:**

Use the clamp hardware specified (the miniscule spacers go between the stamped piece and the top of the PC board).

**U5 Installation:**

Ground contact is provided by using 2 cut-off resistor leads to form hair-pin loops which are inserted from the top, above U5, and soldered to the ground plane. Trim the lower ends to an appropriate length and form to hold U5 upright while soldering these and other leads.

**C5, C6, C7 Installation:**

Install with as close to 'zero lead length' as possible.

**U8, U9 Installation:**

The easiest way of grounding the can on these (solidly) to the ground plane is to first drop an eyelet through the ground hole from the top and sweat it to the ground plane while plugging the hole with a toothpick (to keep it from filling up with solder). The IC may now be dropped in and the ground established by filling the eyelet with solder (solder the other two leads **first** to keep everything in place).

**TESTS**

**Aligning 70 MHz Filter** (shield cover in place)
Without power: Input to L2, temporarily **cut trace** to R7 and U8-2. Output from C17 (lift off U9-1 or J4).
With power (preferred alignment): Input to C18 (lift off R5/R6). Output from J4.

Be sure the generator and load/detector are a true 50 ohm at 70 MHz. Follow this sequence:

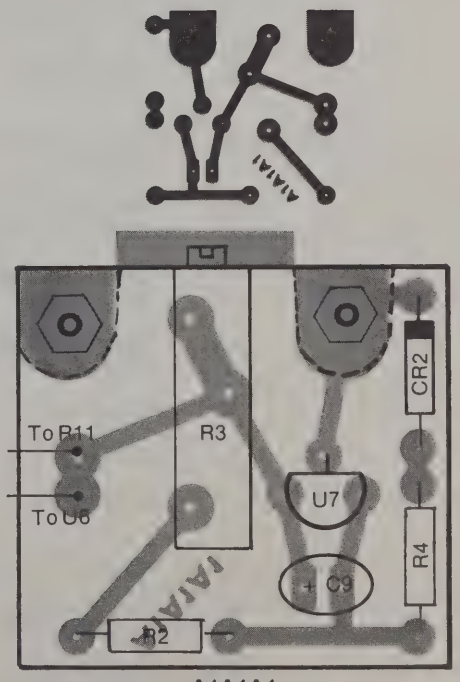
1) Tune L2, L4 and L6 for max at 70 MHz (rough tuning)
2) Tune L3 for a zero (null) at 47.5 MHz
3) Tune L5 for a zero (null) at 92.5 MHz
4) Tune L4 for a max at 70 MHz
5) Tune L6 for a max at 57 MHz
6) Tune L2 for a max at 83 MHz
7) Repeat L4,5 and 6 until no further improvement is noted
8) Adjust high and low notches (L5 and L3) as required to place upper and lower -3 dB points (reference the center of the passband) at 88 and 55 MHz respectively.
9) Sweep the overall response and slightly re-tune as required for the best approximation of:
   a) middle peak centered on 70 MHz
   b) both sides of passband having a more or less 1/2 dB valley, then a peak near the cut-off frequency, with good symmetry (a 'tilt' of approximately 1/2 dB across the passband is normal) allowing a straight line to 'join' the peaks and a parallel line the valleys.
   c) upper and lower 3 dB points at 85 and 55 MHz, relative to peak center response (i.e. symmetrical); primarily controlled by the high and low notches L5 and L3.

**FINAL TESTS**

When fully asembled and with all shielding in place, connect a frequency counter to J3 and set R3 for a frequency of 890.0 MHz at room temperature. The counter should have a 50 ohm input and the resistive terminator on J3 must be replaced after using the counter (the frequency shifts significantly with no load at J3 and unwanted radiation escapes to bother others unnecessarily). **If a counter-prescaler is not available** that will handle this frequency, an alternate method would be to remove temporarily mixer U1 and drive U2 at a high level with an accurate signal generator at a submultiple of 820 MHz. Sufficient level at 820 MHz should be generated to overdrive U2 and this will produce a countable output at the 70 MHz I.F. output with something like -3 dBm at F/3 (273.33 MHz) producing more or less 0 dBm at J4 without U9 (approximately -9 dBm **with** U9). Lower odd submultiples will produce progressively smaller output levels (**do not exceed** 0 dBm drive or damage to U2 and/or U4 could result).

If a microwave power generator is available, overall gain may now be checked by applying a -40 dBm input to J5 (-55 dBm if U9 is installed) and tuning with a 10K (test) pot (preferably 10-20 turn) from C1 **or** C22 to ground. About 7.5 volts across the pot corresponds to 3.7 GHz input while about 28 volts corresponds with 4.2 GHz. Overall gain should be close to 18.9 dB (32.5 dB with U9 installed).

Lacking a microwave signal generator, a signal may be injected at J2 (820 MHz) with an expected gain to J6 of 26 dB (39.6 dB with U9 installed). Or, basic function can be checked by subharmonic injection as described above. This is all **not** very critical since there are no adjustments and if the U2 through U9 devices all have the proper supply voltages and no DC shorts have crept onto the board during construction.




**A1A1A1**
**DOWNCONVERTER SUBASSEMBLY**
**Figure 9A**

**A1A1A1 DOWNCONVERTER SUBASSEMBLY**

**TABLE ONE**
Downconverter Subassembly A1A1 (including A1A1A1)
**Parts List:** (for schematic see figure seven)

| Schematic Designator | Total Qty | Description | Vendor |
|---|---|---|---|
| C1,2,4,8,22 | 5 | 470pF, + /- 20% discoidal feedthru cab (**not** tubular) | Spectrum Controls FA5C-470 pF + /- 20% |
| C5, 7 | 2 | 18pF, + /- 5% NPO disc ceramic | Sprague 10TCC-Q18 Centralab DTZ series |
| C6 [See Page 17] | 1 | 1.2pF, + .5 pF NPO disc ceramic | Sprague 10TCC-V12 |
| C9 | 1 | 1.5uF, + /- 20% 50V dipped tantalum | Sprague 199D155X0050CA1 Kemet T390C155M050 AS |
| C10,11,13,15,16 | 5 | 22pF, + /- 5% NPO | Sprague 10TCC-Q22 |
| C12 | 1 | 10pF, + /- 5% NPO disc ceramic | Sprague 10TCC-Q10 Centralab DTZ series |
| C14 | 1 | 33pF, + /- 5% NPO disc ceramic | Sprague 10TCC-Q33 Centralab DTZ series |
| C17 | 1 | 18pF, + /- 5% NPO disc ceramic | Sprague 10TCC-Q18 Centralb DTZ series |
| C18,19,20*,21* | 4(2*) | 1000 pF, + /- 10% X5P disc ceramic | Sprague ZSS-D10 series |
| CR1 | 1 | 4 (+ /- 0.6 mA) current regulating diode | Motorola MCL 1304 |
| CR2 | 1 | 1N4152 diode | commonly available |
| FL1 | 1 | 820 MHz bandpass filter, custom | Ramsey Electronics (Washburn FL1) |
| J1,2 | 2 | SMA male, PC type | EF Johnson 142-0300-006, or, 142-0300-001 |
| J3, 4 | 2 | BNC female | any UG-1094 type fitting |
| J5 | 1 | N female bulkhead | Amphenol 36250 |
| J5 | 1 | Adapter (#6 hole, 3/8'' dia x 1/4 thk brass spacer) | H. H. Smith #2110 |
| L1 | 1 | .051 uH coil | J. W. Miller 75F518mpc Standex LM-2/4-1/2T #22 |
| L2 | 1 | .091 uH nom coil 3/8'' x 10-32 'J' core | Coilcraft 104-2 1/2T-3/8J-Pos 3 |
| L3,L6 | 2 | .489 uH nom coil 3/8'' x 10-32 'J' core | Coilcraft 112-9 1/2T-3/8J-Pos 3 |
| L4 | 1 | .689 uH nom Coil 3/8'' x 10-32 'J' core | Coilcraft 112-12 1/2T-3/8J-Pos 3 |
| L5 | 1 | .125 uH nom Coil 3/8'' x 10-32 'J' core | Coilcraft 104-3 1/2T-3/8J-Pos 3 |
| L7 | 1 | Choke, 10uH | Delevan 1537-36 |
| P1 | 1 | BNC terminator, 51 ohm | Amphenol 46650-51 |
| P2 | 1 | SMA male for .141 line | EF Johnson 142-0281-006, or, 142-0281-001 |
| R1 | 1 | 470 ohm, + /- 5%, carbon comp, 1/4 w | commonly available |
| R2 | 1 | 20K, + /- 5%, carbon **film** or metal **film** 1/4 w | commonly available |
| R3 | 1 | 10K, + /- 10% 15 or 20 turn Cermet pot | Beckman 89PR 10K Bourns 3006P-1-103 Spectrol 43P103 |
| R4 | 1 | 1.8K, + /- 5%, carbon or metal **film** 1/4w | commonly available |

| | | | |
|---|---|---|---|
| R5 | 1 | 24 ohm, + /-5%,carbon comp, 1/4 w | commonly available |
| R6 | 1 | 120 ohm, + /-5%,carbon comp,1/4 w | commonly available |
| R7 | 1 | 150 ohm, + /-5%,carbon comp,1/4 w | commonly available |
| R8 | | part number not used | |
| R9 | 1 | 180 ohm, + /-5%,carbon comp,1/2 w | commonly available |
| R9* (low gain option) | 1 | 270 ohm, + /-5%,carbon comp,1/2 w | commonly available |
| R10* | 1 | 560 ohm, + /-5%,carbon comp,1/4 w | commonly available |
| R11 | 1 | 4.7K, + /-5%, carbon comp, 1/4 w | commonly available |
| U1 | 1 | Doubly Balanced Mixer | VARI-L DBM-500<br>Engelmann Microwave |
| U2, 4 | 2 | Amplifier, hybrid | Avantek GPD-1002 with mounting hardware |
| U3 | 1 | VTO, 2.4 to 3.7 GHz | Watkins-Johnson V-802 with 251050-001 hardware |
| U5 **[See below]** | 1 | Single balanced mixer H-P 5082-9200 | Hewlett Packard |
| U6 | 1 | VTO .6 to 1 GHz | Avantek (VTO-8060) |
| U7 | 1 | Shunt regulating IC | TI TL 431CP |
| U8 | 1 | Amplifier, IC | Motorola MWA 120 |
| - | 1 | Eyelet for above, see text | Keystone #24 |
| U9* | 1 | Amplifier, IC | Motorola MWA 110 |
| - | 1 | Eyelet for above, see text | Keystone #24 |
| W1 | A/R | .141('') 50 ohm 'hardline' | Times Wire & Cable CLS-50-141-T<br>Cablewave Systems CT.141-50 |
| Z1,2,3,4,5,6*,7 | 7 | Ferrite bead | Fair-Rite Prod. #264-300031 |
| - | 1 | PC board set (A1A1 & A1A1A1 **per figure 8 artwork** | Ramsey Electronics |
| - | 1 | 70 MHz (bandpass) filter shield | Bud CU-124 (use deeper half only) |

***-These parts deleted for low gain option; see test, and schematics**

## Builder's Notes / Downconverter A1A1

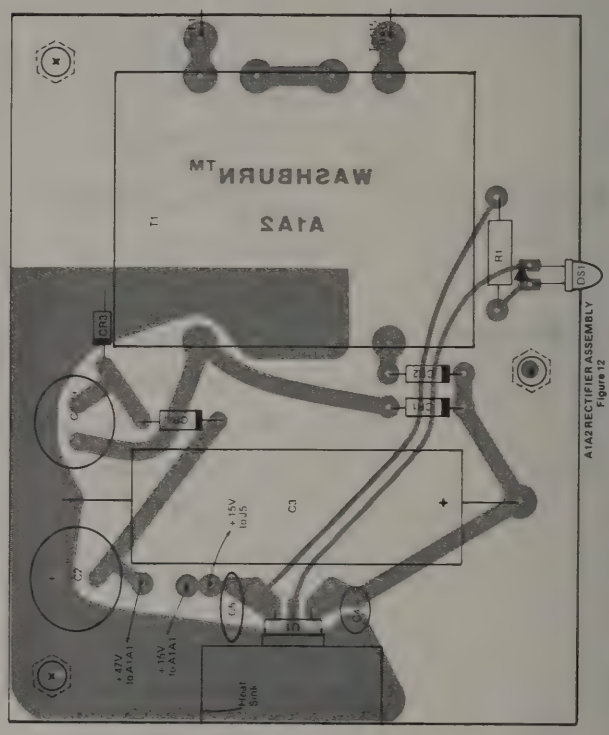
**NOTE REGARDING PARTS C6 and U5**
The Hewlett Packard single balanced mixer (H-P 5082-9200) has been discontinued as this manual is being printed. The parts directly affected are the mixer (identified as U5 here) and capacitor C6. Some of these mixers may still be in distribution parts lines but the supply is short at best. See special update errata on inside back cover.

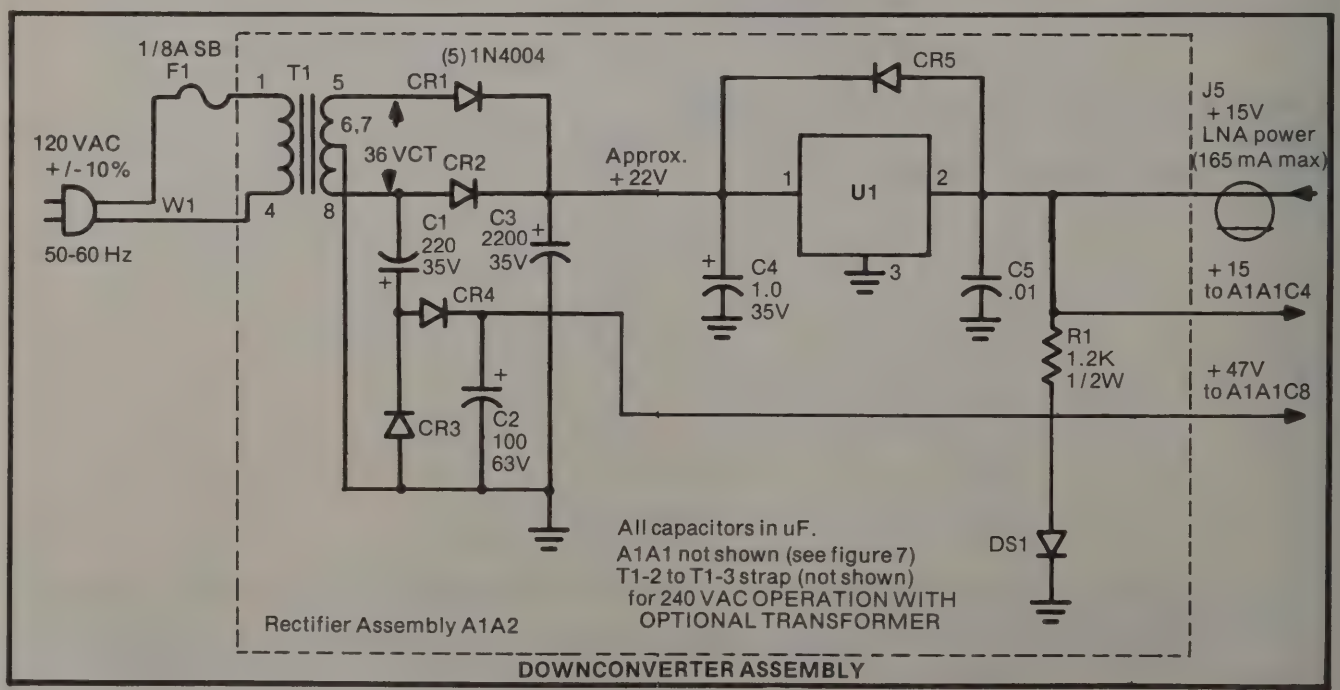
## DOWNCONVERTER ASSEMBLY A1A2

References:
Schematic - see figure 10
Parts list - see table 2
PC artwork - see figure 11
PC assembly drawing - see figure 12

### Theory of Operation

Rectifier assembly A1A2 is a straight forward capacitor input power supply with auxilliary voltage doubler CR3 and 4 plus C1, 2 to provide +47 volts for VTO tuning. U1 provides +15 volts (+/-2%) to both the downconverter modules (whose manufacturers **suggest** +/-1% stability to



realize data sheet performance) and an external LNA (165 mA **maximum** load).

A BNC connector is provided as the LNA power jack and it is suggested that RG-58 be used for power cable (recommended is the C/U version with stranded center conductor where flexibility is desired). Any transient that can break into an uninterrupted coax supply line to the LNA is just as likely to break into the coax to your downconverter and that will wreck havoc with both! Therefore further attempts here to protect the LNA supply line seem like overkill. Protection against AC line transients for both the LNA and the expensive VTO and GPD modules is effected by the relatively high output impedance of T1 (approximately 8 ohms), the large capacity of C3 and the input voltage ratings of C3, C4, C1 and U1 (35 V); calculating out to survival of 100% overvoltage transients of 100 microseconds duration, which is pretty severe.

**No power** (on-off) **switch is provided** since your expensive and inconvenient to service LNA and other modules will 'live' much longer if they are always warmer than ambient (this discourages moisture condensation if damp air does enter). The power drain is minimal (even by 1980 energy conservation standards); less than a night light. A green LED is suggested because it drives many people bats to see a red light glowing in an unoccupied room; green has that 'reassuring' look! The LED is on-purpose connected to the regulated line and only moderately driven so that any significant voltage change will produce a visible brightness change.

**Construction Hints**

There are no special considerations for the power supply, A1A2.

Downconverter A1A1 should mount from the **bottom** of a rectangular cutout in a chassis with a metallic bottom cover, preserving the shield created by the ground plane and filter cover and inhibiting radiation of 70 MHz to channel 3 or 4 of your TV set; as well as the LOs.

**Tests**

Check to see that you have +22 V (+/-20%) on C3. Then check for +15 V at J5. And +47 V (+/-20%) at C2. OK? That's it. You are done. Connect to A1A1 and proceed with testing of that subassembly.

**TABLE TWO**
Downconverter Assembly A1 (including A1A2)
**Parts List:** (for schematic see figure ten)

| Schematic Designator | Total Qty | Description | Vendor |
|---|---|---|---|
| C1 | 1 | 220 uF 35V electrolytic | Sprague 503D227F035PE |
| C2 | 1 | 100 uF 63V electrolytic | Sprague 503D107F063PE |
| C3 | 1 | 220 uF 35V electrolytic | Sprague 501D228F035TV |
| C4 | 1 | 1.0 uF, +/-20%, 35V dipped tantalum | Sprague 199D105X0035BB1<br>Kemet T390B105M035AS |
| C5 | 1 | .01 uF, 50V disc ceramic | Centralab UK-50-103 |
| CR1,2,3,4,5, | 5 | Rectifier,1 amp,100 PIV | 1N4002,4003,4004,4005,4006,4007 |
| DS1 | 1 | LED, green | HP 5082-4955 |
| F1 | 1 | Fuse, 3AG, 1/8 amp Slow Blow | commonly available |
| F1 | 1 | Fuse holder, panel, 3AG | Littlefuse 342028 |
| J5 | 1 | BNC female | any UG-1094 |
| T1 | 1 | Power transformer, 36 VCT, .35A, 115VAC 50-60 Hz | Signal Transformer ST-5-36 |
| (T1) **for 230 VAC system** | 1 | Power transformer, 36 VCT .35A, 230VAC 50-60 Hz | (DST-5-36) |
| U1 | 1 | Voltage Regulator,TO-220, +15V, +/-2% | National LM340AT-15 |
| U1 | 1 | Heat sink | Thermalloy 6030B-TT |
| W1 | 1 | Two wire power cord | commonly available |
| - | 1 | PC board (A1A2) **per figure 11 artwork** | Ramsey Electronics |

**PLL DEMOD ASSEMBLY A2A1A1**

References:
Schematic - see figure 13
Parts list - see table 3
PC artwork - see figure 14
PC assembly drawing - see figure 15

**Theory ofOperation**

The PLL demodulator receives its input signal from the downconverter through up to:

100' of RG-58
150' of RG-58 foam
200' of RG-8
300' of RG-8 foam

This assures less than 1 dB of 'tilt' across the 55 to 85 MHz I.F. passband.

Gain set control R1 provides a rear-panel accessible control of the input level, to stay within the signal strength meter's 20 dB range (and the AGC'd stages' 25 to 30 dB range) on both signal and noise so that CNR and signal level can be periodically checked to head off problems like moisture accumulating in cables, the sun frying your LNA and so on.

U1 is a Plessey device that is ideal for the purpose, being quite flat to over 100 MHz and with a slight gain upward tilt in the 55 to 85 MHz region (that nicely cancels the typical filter and cable downward tilt). The AGC input (pins 2 and 3) is a diode to ground and gain control (within the range possible) is proportional to current, providing an automatic log conversion. Emitter follower Q2 cancels the temperature sensitivity of the AGC diode while operating at a constant current so that the voltage change with AGC is passed through. This voltage leaves C3 and is processed elsewhere.

The output of U1 is coupled to AGC detector U2 (which is also an amplifier whose output is **not** used due to a nasty downward tilt in the range of interest). It is a respectable average value detector which means that pure noise (no signal) will register 1.1 dB lower than its true value relative to a signal. Error in AGC control for CNRs of interest (i.e. greater than 8 dB) is a small fraction of a dB, making the loop dynamics essentially independent of signal level. Inverter Q1 provides a handy place to hang a large filter capacitor to eliminate meter flutter on noise.

The output of U1 is also coupled to U5A which is a MECL III Exclusive-OR gate biased to the center of its transition region by U5B and U5C strapped around each other in a negative feedback loop. U5A is driven by the AGC'd input signal at a level that provides 680 mV P-P output; 80% of the maximum possible. By applying VCO U6's output to U5A's other input we cause it to function as a phase detector with two characteristics especially important for **low threshold** operation:

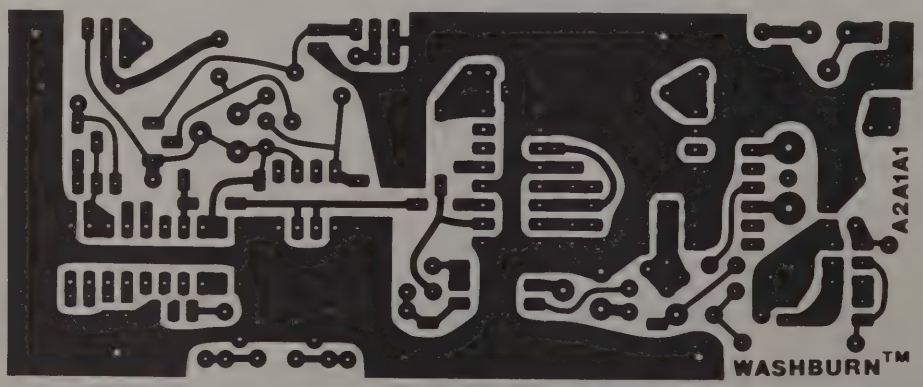
1)**The input noise has a recurrent peak**-to-average ratio of about 10 dB which means for the input CNR range of interest (8 to 14 dB) peak noise levels and signal levels are closely comparable. By operating the phase detector at a closely controlled point just below a non-saturating dipping threshold, noise that is momentarily **in phase** with the signal produces a smaller output perturbation than expected since the phase detector output is the **product** of the signal and LO inputs; and, the signal input has not been allowed to increase substantially.

2)**Momentarily out of phase noise** comes very close to nulling the signal and causes the product output of the phase detector to drop to a low level, which effectively reduces the loop gain and inhibits the VCO from fully following the noise induced phase perturbation.

The loop is closed by a feedback path consisting of inverter Q3 driving an emitter follower Q5 (ignore the collector circuitry of Q5 for the moment). The use of Q5 to drive U6 and the absence of the manufacturer's suggested bypass on pin 12 of U6 are the result of a detailed analysis of the internal operation of the 1658 multivibrator VCO and result in **ruler straight deviation from 30 to 110 MHz**; far beyond the capability of the 564 type devices, **and necessary** as discussed below.

The two distinguishing features of the PLL are:

1)Its closed loop resistance is 1st order, the



only loop filter 'break' being C26 at 130 MHz which 'lightly' attenuates the 2F (and higher) output components of the phase detector so as to not exceed the slew rate capability of Q5/Q6.

2)It is **extremely** wideband (-3 dB at 27 MHz).

**Why is this?** Have we not all been brought up to believe 2nd order loops are the right answer to any question and the narrower a loop the better it rejects noise? Like most generalities these are half truths so let's discuss the other half:

The first order loop has two virtues of special value for a video demod.

1)Because it tracks the signal in phase rather than up to 90° out like a 2nd order loop, if it momentarily looses lock it can snap right back in, rather than going through a lengthy re-acquisition trajectory. **This produces a 'spot' sparklie rather than a streak.**

2)Since it is not always trying to reduce the phase error to zero, as does a 2nd order loop, it can be set up for equal peak phase error for positive **and** negative deviations reducing the chance a break in lock will occur at either extreme. The 2nd order loop slews toward zero phase error only to be 'surprised' by the next abrupt phase change and produces a larger phase error (and dramatically higher chance of a sparklie) as a result.

It is wideband because there is a body of knowledge establishing that a bit error (a sparklie to us) is least likely in a first order loop when the noise bandwidth is 3-1/2 to 4 times the peak deviation. This equates to a -3dB BW of 2.2 to 2.5 times the peak deviation giving us more or less 27 MHz at -3 dB for a deviation of 11 MHz. Once again, **Klapper and Frankle** (chapter 9) is a good reference for an understanding of why this is true.

The video baseband is extracted from the loop at the collector of Q5 with C27, L3, C29 and L4 forming a four pole Butterworth filter with a -3 dB point at approximately 8.4 MHz (the filter has been broken into a realization with two poles, as we often do with op-amp active filters). Again, the bandwidth is quite wide to allow very flat response in the video range up to 4.2 MHz, and to preserve the audio and data subcarriers (i.e. approximately -1 dB at 6.8 MHz).

Q7 acts as a common-emitter video amp and produces a respectable 189 mV P-P (nominal) video output level to the processor assembly via W2 and P1. An output zero control, R9, is provided to allow the signal to be centered in the range of the video amps (and AFC) to follow.

Local regulation of the required +6 and -5.2V supplies is provided with the regulator ICs heat sunk to the shield box to minimize interior heating.

**Construction Hints**

Coax W1, although short, really is necessary; the brutal MECL III rise times ring like mad on open wires over 1/2'' or so in length.

All the 10K pF bypasses should be kept tight to the PC board (short leads); again, fast rise times to cope with.

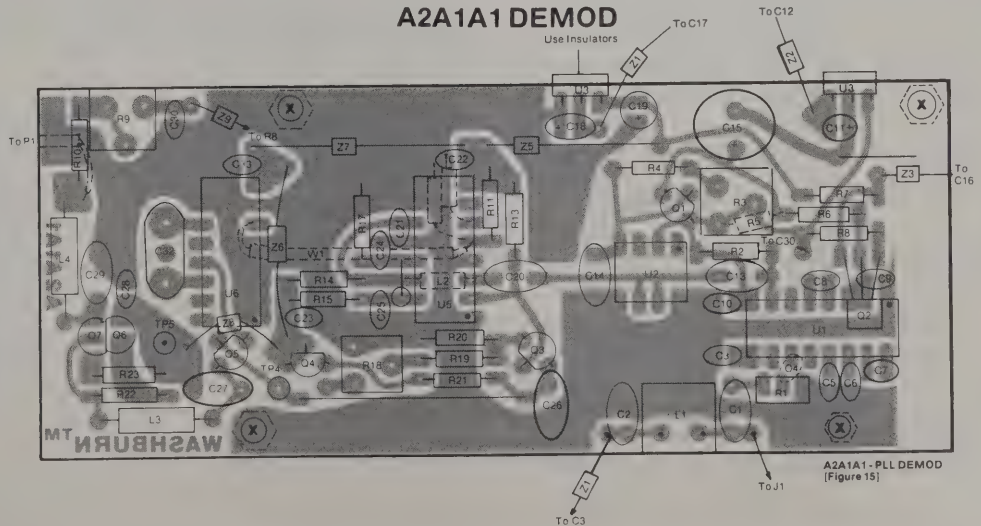
The shield box cover should be drilled 1/4'' for tuning C32, R9 and R18 with 3/16'' holes over TP4 and TP5 for access.

**Tests**

1)Apply power to the PC board and set R1 to midrange. Connect a high impedance voltmeter from TP1 to TP2 and apply a 70 MHz input signal to J1 at about -28 dBm. Vary the signal level and verify that AGC levels from zero to over 2.6 V can be obtained from TP1 to TP2. Also verify that the voltage at C16 varies from approximately 200 mV over the **same** range of inputs.

2)Set the signal level for 1.3 V at TP1-2 and disable the VCO by connecting the banded end of a germanium diode (or hot carrier diode) to U6-11 or 14, with the other end to ground. Connect an **accurate** Hi-Z voltmeter from TP3 to ground or use an RF detector probe calibrated on an accurate signal generator output at 70 MHz. Set R18 to midrange and adjust R3 for 240 mV RMS at TP3 (680 mV P-P). **R3 should not be adjusted again** unless the board is serviced and then only if the

**A2A1A1 DEMOD**




A2A1A1 - PLL DEMOD
[Figure 15]

above procedure is followed.

3)Connect the DC voltmeter from TP4 to TP5 and adjust R18 for 1.48V. Remove the diode disabling U6 and connect a counter from TP6 to ground through a 470 ohm resistor. As C32 is tuned (**with an insulated tool**) the loop should come into lock at 70 MHz (adjust generator frequency slightly if required) with further adjustment of C32 varying the voltage at TP4-5. Set C32 to **return** this voltage to 1.48V.

4)Connect the DC voltmeter to P1 center pin and **verify** that the output can be zeroed with R9.

5)If you wish to check video frequency response (**optional**) proceed as follows. Connect a 75 ohm terminating resistor to P1 and inject a second signal generator as follows:

a)Terminate the coax from the generator with a 51 ohm resistor directly across its ends (this avoids high currents on the board that might distort readings).

b)Connect the coax shield to a ground **near** U6 and connect the center conductor to TP7 **through a 3.3K resistor in series with a .05 UF ceramic capacitor.**

You may now directly modulate the VCO with video frequencies (up to 27 MHz) through this entirely independent frequency control port, allowing you to observe the actual loop video response at P1. Note that the overall Butterworth (filter) response is a result of C27/L3 producing a gradual roll-off, while C24/L4 produces a peaked response which cancels the roll-off until the peak is reached, at which point the output rolls off rapidly as frequency is further increased.

6)Final alignment should be performed with the shield fully closed-up and after 1 hour warmup (apply an input signal at the **same level** as used above).

a)Disable the VCO sticking the banded end lead of a germanium or hot carrier diode into the hole above C32 and touching the other end to the edge of the hole (ground).

b)Connect a DC voltmeter to TP4 and TP5 by sliding 1K 1/4 watt resistors covered with protective sleeving into the holes over these test points and until they rest on the test point receptacles.

c)Adjust R18 for 1.48V and remove the diode disabling U6.

d)Adjust C32 to return to 1.48V (**insulated tool**).

e)Connect the DC voltmeter to P1 and adjust R9 for a zero reading.

7)Since the average DC value of normal video is not the same as the center of its deviation extremes, the following optimization should be performed (preferably while receiving a standard split-screen color bar pattern such as one finds on transponders 12, 23 and 24 during the normal daytime hours):

a)Choose a signal level that is the 7 to 9 dB CNR region [*]. If you have a standard or higher margin system this can be done by purposefully mis-aiming the antenna slightly to bring the carrier level down to this range. **The AFC should be on.**

B)Note that as A2A1 R9 is rotated in either direction from the position set in step 6 there will be a point where there is a fairly **abrupt** increase in sparklies (white in one direction from the original setting, black in the opposite direction). The correct setting-adjustment is midway between these two sparklie-points.

***-Make CNR measurements with the front panel 'Signal Strength' meter or another average-reading device.**

Broadband noise will indicate 1.1 dB **below** its true value so take the reading obtained on an unused transponder (i.e. 4, 16 or SATCOM F1) and **add** 1.1 dB for the 'noise reference level'.

When tuned to an **active** transponder channel the metering will indicate not CNR (carrier to noise ratio) but rather carrier **plus** noise to noise (ratio); or CNNR. This can be readily converted to CNR as follows:

a)Subtract the **corrected** 'noise reference level' from the signal reading to obtain carrier + noise/noise ratio in dB.

b)Convert this to a power Ratio:

$$\text{Power Ratio} = 10^x \text{ where } x = \left\{ \frac{\frac{C+N}{N}}{10} \right\} \text{ in dB.}$$

c)Subtract one from that ratio; i.e. if C + N/N = 10 dB = 10 power ratio, we subtract 1 leaving a corrected ratio of 9.0.

d)Now take the **log** of this number and multiply by 10; For example, log 9 = .954, which X 10 equals 9.54 dB. This is the **true** CNR of this example (recall that the original uncorrected reading was for a 11.1 dB difference).

For convenience here is a tabulation of CNR vs **meter-reading-difference** over the range of interest:

| Meter Reading Difference | True CNR |
|---|---|
| 8 dB | 5.9 dB |
| 9 dB | 7.1 dB |
| 10 dB | 8.3 dB |
| 11 dB | 9.4 dB |
| 12 dB | 10.5 dB |
| 13 dB | 11.6 dB |
| 14 dB | 12.7 dB |
| 15 dB | 13.7 dB |
| 16 dB | 14.8 dB |
| 17 dB | 15.8 dB |

**TABLE THREE**
PLL Demodulator Assembly A2A1A1
**Parts List:** (for schematic see figure thirteen)

| Schematic Designator | Total Qty | Description | Vendor |
|---|---|---|---|
| C1,2,14 | 3 | 1000 pF, + /- 10% X5P disc ceramic | Sprague 2SS-D10 |
| C3,4,5,6,7,8,9,10 21,22,23,24,25,28, 30,31,33 | 17 | .01 uF + /- 20% 'Redcap' 651 type | Erie 8121-050-651-103M (others cross reference) |
| C11,19 | 2 | 1.0 uF, + /- 20% 25V dipped tantalum | Sprague 199D105X0025AB1 Kemet T390A105M025AS |
| C12,16,17 | 3 | 470 pF + /- 20% discoidal | Spectrum Controls FB2B-470pF, + /- 20% **with** M6377 nut & M-6351 L washer |
| C13,20 | 2 | 470 pF + /- 10% X5P disc ceramic | Sprague 10SS-T47 |
| C15 | 1 | 220 uF 10V electrolytic | Sprague 503D227F010NC |
| C18 | 1 | 2.2 uF + /- 20% 16V dipped tantalum | Sprague 199D225X0016AB1 Kemet T390A225M016A5 |
| C26 | 1 | 12 pF + /- 5% NPO disc ceramic | Sprague 10TCC-Q12 Centralab DTZ series |
| C27 | 1 | 91 pF + /- 5% dipped mica, CM05 size | MIL #CM05FD910J03 (many vendors use this #) |
| C29 | 1 | 220 pF + /- 5% dipped mica, CM05 size | MIL #CM05FD221J03 |
| C32 | 1 | 1-10 pF multi-turn trimmer capacitor | Sprague-Goodman GHT 10000 |
| CR1 | 1 | Silicon signal diode | 1N4148, 1N4152, 1N4448, 1N4454 |
| J1 | 1 | BNC female | Any UG-1094 |
| L1 | 1 | Coil, shielded, 2.2 uH (**used as RFC**, slug full in) | Cambion 558-7107-17 |
| L2 | 1 | RF choke, .39 uH, + / 10% miniature | Delevan 1025-10 |
| L3 | 1 | RF choke, 3.3 uH, + /-10% | Delevan 1537-24 |
| L4 | 1 | RF choke, 2.2 uH, + /- 10% | Delevan 1537-20 |
| P1 | 1 | Phono plug | Switchcraft 3501 MC |
| Q1 | 1 | 2N4126 | commonly available |
| Q2 | 1 | 2N5089 | commonly available |
| Q3,4,5, | 3 | 2N4258 | commonly available |
| Q6 | 1 | 2N4124 | commonly available |
| Q7 | 1 | 2N4401 | commonly available |
| R1 | 1 | 50 ohm, + /- 10%, 3/8'' square side adj. Cermet pot | Bourns 3386C-1-500 (and many others) |
| R2 | 1 | 750 ohm, + /-5% carbon comp, 1/4 w | commonly available |
| R3 | 1 | 1K + /- 10% 3/8'' square top adj. Cermet pot | Bourns 3386F-1-102 (and many others |
| R4 | 1 | 810 ohm + /-5% carbon **film**, 1/4 w | commonly available |
| R5 | 1 | 510K, + /-5%, carbon comp, 1/4 w | commonly available |
| R6 | 1 | 1.3K, + /-5%, carbon comp, 1/4 w | commonly available |
| R7 | 1 | 6.8K, + /-5%, carbon comp, 1/4 w | commonly available |

| | | | |
|---|---|---|---|
| R8,16 | 2 | 1K, + /-5%,carbon comp, 1/4 w | commonly available |
| R9,18 | 2 | 500 ohm, + /-10%, 3/8'' square top adj. Cermet pot | Bourns 3386F-1-501 (and many others) |
| R10 | 1 | 680 ohm, + /-5%,carbon **film**,1/4 w | commonly available |
| R11 | 1 | 130 ohm + /-5%,carbon comp,1/4 w | commonly available |
| R12 | 1 | 82 ohm + /-5% carbon comp,1/4 w | commonly available |
| R13,14,15 | 3 | 270 ohm + /-5%,carbon comp,1/4 w | commonly available |
| R17 | 1 | 9.1K + /-5%,carbon comp,1/4 w | commonly available |
| R19 | 1 | 1.2K + /-,carbon **film**, 1/4 w | commonly available |
| R20 | 1 | 120 ohm, + /-, carbon **film**, 1/4 w | commonly available |
| R21 | 1 | 100 ohm, + /-5%,carbon **film**, 1/4 w | commonly available |
| R22 | 1 | 300 ohm, + /-,carbon **film**, 1/4 w | commonly available |
| R23 | 1 | 30 ohm, + /-5%,carbon **film**, 1/4 w | commonly available |
| TP4,5 | 2 | Test point receptacle | EF Johnson 105-0851-001 (white, any color OK) |
| U1 | 1 | Amplifier with AGC | Plessey SL550D(or SL550C) |
| U2 | 1 | Detector/Amplifier | Plessey SL1613C |
| U3 | 1 | Voltage regulator,TO-220, +6.0V + /-5% | Any 7806 or 78M06 (TO-220) |
| U4 | 1 | Voltage regulator, TO-220, -5.2V + /-5% | National LM320T-5,2 Signetics 7905.2 CU |
| - | 1 | Set insulating hardware for U4 | (mica and shoulder washer) |
| U5 | 1 | Triple Exclusive OR gate | Plessey SP1674 |
| U6 | 1 | Emitter-Coupled Multivibrator | Plessey SP1658 |
| W1 | A/R | 50 ohm sub-miniature coax | (RG-178 B/U) |
| W2 | A/R | 75 ohm miniature coax | (RG-179 B/U) |
| Z1,2,3,4,5, 6,7,8,9,10 | 10 | Ferrite bead | Fair-Rite Prod. #264-300031 or 2743001112(**built-in leads**) |
| - | 1 | PC Board (A2A1A1), **per figure 14 artwork** | Ramsey Electronics |
| - | 1 | Shield Box | Bud CU-3004A |

**PROCESSOR ASSEMBLY A2A1**

References:
Schematic - see figures 16 and 19
Parts list - see tables 4 and 5
PC artwork - see figure 17
PC Assembly drawing - see figure 18

**Theory of Operation**

The processor consists of four major sections.

**Power Supply:** There is nothing unusual here. Although a power switch can be provided or installed, the best advice is to turn the unit on and leave it operating; continuous operation is recommended. Switch Q3 is activated by the Odd-Vertical/Even-Horizontal switch on the remote control and provides power to a relay in the rotor control assembly.

**Video Processing:** U1 provides both accurate CCIR deemphasis and video level adjustment via R4. The NE5539 device is a rather remarkable op amp with a gain bandwidth product of 1.2 GHz, assuring that the frequency reponse will be wholly controlled by feedback network R3, R4, R5, R6, R7 and C3. U1 provides outputs to video buffer U2 and the two sound I.F. assemblies, via J2 and J3.

U2 serves as a unity gain buffer that can be DC switched from inverting to non-inverting by FET Q1. Its full output drive capability is used for dispersion clamp CR1. The clamp circuitry consists of C11, which during each video line is very lightly charged by R14 and CR1, a controlled conductance diode that forces the sync tip to the same voltage following **each** video line. The net result is that each line begins at the same **reference level** with almost no variation due to the presence of the (30 Hz) dispersion waveform. Note that no video lowpass filtering has been used (other than at 8.4 MHz in the PLL video output). For VCR interface none is needed since the very first thing encountered in the VCR is a very good video filter which is in-line even when only using it as a modulator. Disturbance of the clamp by a sound subcarrier, or worse by the envelope difference between the two subcarriers, is prevented by L1 and R15 which have no effect during the relatively long sync tip, but convert CR1 to an average detecting (choke input) rectifier for subcarrier frequencies. Since the subcarriers have

no DC average of their own, they are ignored by the clamp.

Inverter Q2 provides a standard negative sync output of 1V P-P into 75 ohms for the VCR.

**Tuning and AFC:** Shunt regulator U4 performs an interesting function; it makes the receiver think the first conversion VTO, A1U3, has a linear voltage vs frequency curve. The device acts much like a 3 lead op amp in that the output always moves to maintain a constant voltage at the sense (**side**) terminal. Thus any current change induced at the side terminal causes an equal current change in the resistor from the top terminal to the side terminal, and a voltage change at the top terminal proportional to the value of the top-to-side resistor. Well, if we place the sense terminal at the right voltage (-1.25V in this case) it turns out that **adjusting the value of the top-to-side resistor to change the top voltage also changes the voltage gain** with respect to the same current injected at the side **in a manner that exactly tracks the change in modulating sensitivity of the VTO.** Presto...AFC

applied at the sense (side) terminal always has the same effect **in MHz**, regardless of the tuning voltage being used. Yet another advantage accrues, in that the 20 MHz offset required when switching from horizontal to vertical transponders can be generated by simply switching one resistor from the sense terminal to ground!

S3 affects the choice of either the front panel manual tuning control (for noise checks and experimentation) or the preset pots in the remote control assembly. U5 supplies approximately -3.75V, adjustable to get the -1.25V desired, at the sense terminal of U4. CR2 provides some temperature compensation of VTO and A1U3. If the downconverter must be subjected to greater temperature extremes than found in a home or its basement jumper 'W1' can be removed and a 250 ohm pot inserted to allow 'seasonal correction' of the VTO temperature drift (the VTOs are **not** rated for use **below 0 degrees C** and we would advise using thermostatic cable to keep them above that temperature, at least).

The PLL detector output at J1 is amplified by AFC loop filter stages U3A and U3B and applied as AFC to U4 via S4B and R27. The gain constants are such that the AFC has an unity gain frequency of 165 Hz, with integrator U3B causing the gain to rise at 6 dB per octave **below** that frequency, providing an additional 15 dB of dispersion rejection and effectively eliminating the need for any additional I.F. filter bandwidth for dispersion. **Above** 165 Hz U3B causes the gain to decrease at 6 dB per octave up to 600 Hz, where R21/C15 **increases** the rate of cutoff to 12 dB per octave. Thus **at 15.75 kHz** line rates the AFC gain is -68 dB insuring no distortion of the desired video.

U3B also drives center tuning meter M2 via E3, which indicates (AFC 'on') how much of the available AFC range is being used. Because U3B is an integration with no DC feedback, there is no tuning error until we actually exceed the AFC range. The AFC may be disabled via S4, for purposes such as CNR checks where AFC would make it hard to read the noise level on an unused transponder. When in this mode feedback resistor R24 causes U3B to act as a meter amplifier giving a + /-10 MHz discriminator center tuning display.

**Audio Processing:** Audio from the sound I.F.s (plugged in at J2 and J3) is summed by U6A (actually only one will be 'on' at a time), amplified, and sent to E21 as VCR audio, and U10 the DC volume control stage.

U10 is a balanced modulator IC set up as an amplitude modulator, with a DC control voltage as the 'modulating' signal. Common base audio input, at U6-3, is used to provide the lowest possible distortion. The DC operating points are such that the upper 2/3rds rotation of the volume control gives a 40 dB log increase in audio level while below 1/3rd rotation CR12 and CR13 cause the attenuation to rise over 90 dB. This assures there will be no annoyance from the HiFi speaker when not using the satellite receiver even if power is left on.

U6B serves as an amplifier for the PLL signal strength output, providing control of both zero point and scale compression on the signal strength meter (M1).

Q4 through Q7, DS2 and 3 and S5 form a pair of Schmidt triggers that sense whether either sound I.F. has an input signal, and if so, lights the appropriate front panel LED. S5 allows selection of which is to have priority; i.e. if both are on, which will be 'heard'.

**Construction Hints**

There are no special construction considerations for this assembly other than seating the switches squarely so proper panel alignment is obtained and checking LED fit at the panel before soldering.

**Testing:**

**Video Processing** - The only adjustment here is virtually the last one made; set R4 for 1V P-P at E1 with a 75 ohm load (ignore the audio/data subcarriers which 'fuzz' the scope display waveform). Be sure the video on which this is set has a really full **white** area (the color bar patterns transmitted prior to programming on the premium service transponders is ideal for this). R4 may be set to mid-range initially.

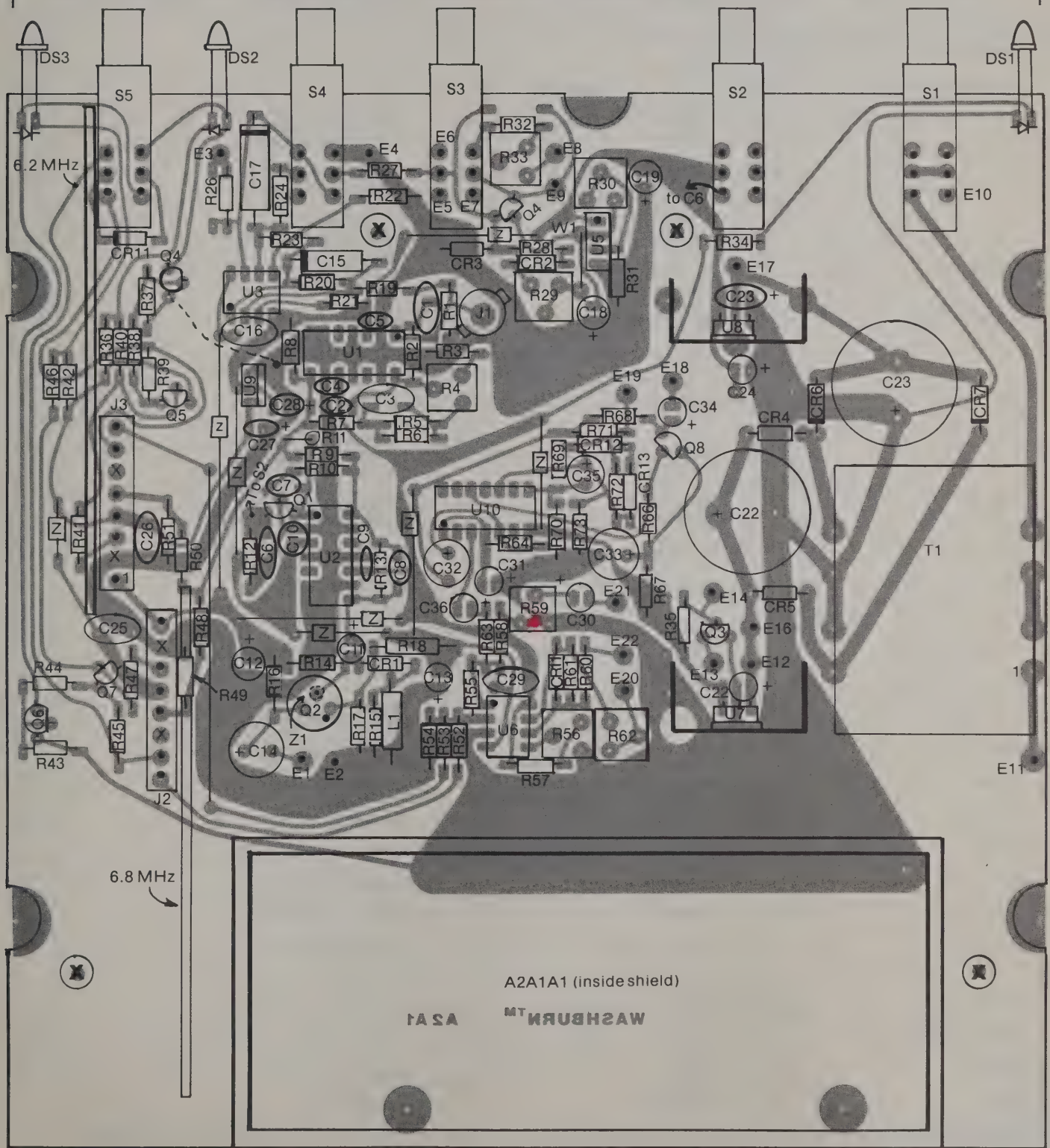
**Power supply** - Check for + /-12V(+ /-20%) at E16 and E17 respectively, and + /-8V at U7-2 and U8-2 respectively.

**Tuning and AFC** - Verify that your manual tuning pot **is** 25K (+ /-10% **maximum**). The front panel should then be marked as follows (expressed in terms of percent of maximum **actual** resistance of the manual tuning pot A2R1, figure 19):

| Transponder | % of Maximum Resistance |
|---|---|
| 1 | 5.8% |
| 2 | 7.6% |
| 3 | 9.4% |
| 4 | 11.3% |
| 5 | 13.2% |
| 6 | 15.6% |
| 7 | 18.0% |
| 8 | 20.6% |
| 9 | 23.3% |
| 10 | 26.0% |
| 11 | 28.8% |
| 12 | 31.6% |
| 13 | 34.9% |
| 14 | 38.0% |
| 15 | 41.2% |
| 16 | 45.1% |
| 17 | 49.2% |
| 18 | 53.2% |
| 19 | 57.4% |
| 20 | 61.8% |
| 21 | 66.4% |
| 22 | 70.9% |
| 23 | 75.8% |
| 24 | 80.6% |

Allow at least one hour warm-up for the whole system and then set R30 for -1.25V as measured at TP1. Place the receiver in the local control mode and then use A2AR1 R8 (primarily the low end) and A2A1 R29 to set the end transponders (1 and 23 or 2 and 24) so that they come out on the proper dial markings. The balance should be quite close. Now move to the Remote Control section for remote preset adjustments.

**Audio Processing** - Apply an input signal at 70 MHz from a signal generator to the PLL demod at the (carrier) level that produced 1.3V from TP1 to TP2 during the PLL tests. Now **reduce** the input level 16 dB and **zero** the signal strength meter using A2A1 R56. **Increase** the level above this **new reference level** by 5 dB and then 15 dB noting how




A2A1 PROCESSOR SUBASSEMBLY
Figure 18

well the meter registers these changes. Use A2A1 R62 to set the scale expansion so that the **change** from +5 to +15 dB creates a 10 dB **scale change**, ignoring what the level really is. Now **step** up and down the scale **2 dB at a time** noting how well the meter tracks the change. If serious mis-tracking is noted at one end, the zero control (R56) can be used to **shove** that end of the range off scale, moving us toward a more linear region. Continue to 'massage' the adjustments for minimum error, concentrating on best accuracy for a 10 dB change between any two points on the scale (i.e.; +0 to +10, +2 to +12, +4 to +14 etc.) since this is typical fo what CNR checks will produce.

**TABLE FOUR**
Processing Assembly A2A1 (**not** including A2A1A1)
**Parts List:** (for schematic see figure sixteen)

| Schematic Designator | Total Qty | Description | Vendor |
|---|---|---|---|
| C1 | 1 | 33pF + /- 5% disc ceramic | Sprague 10TCC-Q33<br>Centralab DTZ series |
| C2 | 1 | 3.0 pF + /- .5 pF NPO disc ceramic | Sprague 10TCC-V30<br>Centralab DTZ series |
| C3 | 1 | 200 pF + /- 5% dipped mica, CM05 size | MIL #CM05FD221J03<br>(most vendors use this #) |
| C4,5,9,10 | 4 | .01 uF + /- 20% 'Redcap' type 651 | Erie 8121-050-651-103M (others cross reference to this #) |
| C6,16,25,26,29 | 5 | .01 uF 50V disc ceramic | Centralab UK-50-103 |
| C7 | 1 | 30 pF + /-5% NPO disc ceramic | Sprague 10TCC-Q30<br>Centralab DTZ series |
| C8 | 1 | 2.7 pF, + /- .5 pF, disc ceramic | Sprague 10TCC-V27<br>Centralab DTZ series |
| C11 | 1 | 1.5 uF + /- 20% dipped tantalum, 25 V | Sprague 199D155X0025AB1<br>Kemet T390A155M025A5 |
| C12,13,27 | 3 | 22 uF + /- 20% dipped tantalum, 10V | Sprague 199D106X0010BB1<br>Kemet T390B106M010AS |
| C14 | 1 | 330 uF electrolytic, 10V | Sprague 503D337F010ND |
| C15 | 1 | .0022 uF + /-10% mylar, 100V | CDE WMF1D22 |
| C17 | 1 | .01 uF + /- 10% mylar, 100V | CDE WMF1S1 |
| C18,22,24 | 3 | 1.0 uF, + /- 20% dipped tantalum 25V | Sprague 199D105X0025AB1<br>Kemet T390A105M025AS |
| C19,23,28 | 3 | 2.2 uF + /- 20% dipped tantalum, 16V | Sprague 199D225X0016AB1<br>Kemet T390A225M016AS |
| C20,21 | 2 | 4700 uF electrolytic, 16V | Sprague 503D478F016UJ |
| C30,31 | 2 | 47 uF electrolytic, 10V | Sprague 503D476F010LA |
| C32,33 | 2 | 220 uF electrolytic, 16V | Sprague 503D227F016ND |
| C34,36 | 2 | 6.8 uF electrolytic, 25V | Sprague 503D685F025KA |
| C35 | 1 | 100 uF electrolytic, 10V | Sprague 503D107F010MB |
| CR1 | 1 | 1N4448 | commonly available |
| CR2,12, 13 | 3 | 1N4152 | commonly available |
| CR3,11 | 2 | Silicon Signal Diode | 1N4148,4152,4448,4454 |
| CR4,5,6,7,9,10 | 6 | Rectifier, 1A, 100 PIV | 1N4002,4003,4004,4005,4006,4007 |
| CR12,13 | 2 | 1N4152 | commonly available |
| DS1 | 1 | LED, green | H-P 5082-4955 |

| | | | |
|---|---|---|---|
| DS2,3 | 2 | LED, amber | H-P 5082-4555 |
| J1 | 1 | Phono Jack | Switchcraft 3501FP |
| J2,3 | 2 | 8 pin plug (**remove** pins 2&6) | Molex 09-64-1081 |
| L1 | 1 | RF choke, .56 uH, + /-10% | Delevan 1537-07 |
| Q1 | 1 | JFET switch | Siliconix or National J112 |
| Q2 | 1 | 2N2219 | commonly available |
| Q3,8 | 2 | 2N4124 | commonly available |
| Q4,6 | 2 | 2N4126 | commonly available |
| Q5,7 | 2 | 2N5089 | commonly available |
| R1 | 1 | 75 ohm + /-5%,carbon comp,1/4 w | commonly available |
| R2 | 1 | 50 ohm + /-5%,carbon comp,1/4 w | commonly available |
| R3 | 1 | 82 ohm + /-5%,carbon **film**,1/4 w | commonly available |
| R4 | 1 | 200 ohm + /-10% square top adj., Cermet pot | Bourns 3386F-1-201 (and many others) |
| R5,6 | 2 | 8.2K + /-**2**% carbon or metal **film**,1/4w | commonly available |
| R7 | 1 | 820 ohm + /-**2**% carbon or metal **film**, 1/4 w | commonly available |
| R8 | 1 | 470 ohm + /-5%,carbon comp,1/4 w | commonly available |
| R9 | 1 | 910 ohm, + /-**2**% carbon or metal **film**, 1/4 w | commonly available |
| R10 | 1 | 82 ohm + /-5%,carbon comp,1/4 w | commonly available |
| R11 | 1 | 820 ohm + /-5%,carbon **film**, 1/4 w | commonly available |
| R12 | 1 | 100K + /-5%,carbon comp, 1/4 w | commonly available |
| R13 | 1 | 1K + /-**2**% carbon or metal **film** 1/4 w | commonly available |
| R14,38,44 | 3 | 8.2K + /-5%,carbon comp,1/4 w | commonly available |
| R15 | 1 | 24 ohm + /-5%,carbon comp,1/4 w | commonly available |
| R16 | 1 | 75 ohm + /-5% carbon **film**, 1/4 w | commonly available |
| R17 | 1 | 130 ohm + /-5% carbon **film**, 1/4 w | commonly available |
| R18 | 1 | 180 ohm + /-5% carbon **film**, 1/4 w | commonly available |
| R19 | 1 | 7.5K + /-5% carbon **film**, 1/4 w | commonly available |
| R20,24 | 2 | 120K + /-5% carbon **film**, 1/4 w | commonly available |
| R21 | 1 | 6.8K + /-5%,carbon comp, 1/4 w | commonly available |
| R22 | 1 | 27K + /-5%,carbon comp, 1/4w | commonly available |
| R23 | 1 | 27K + /-5%, carbon **film**, 1/4 w | commonly available |
| R25 | | part designator not used on schematic | |
| R26 | 1 | 5.6 + /-**2**% carbon or metal **film**,1/4w | commonly available |
| R27 | 1 | 270K + /-**2**% carbon or metal **film**,1/4w | commonly available |
| R28 | 1 | 1.3K + /-5% carbon **film**, 1/4 w | commonly available |
| R29,56,62 | 3 | 1K + /-10% 3/8'' square top adj. Cermet Pot | Bourns 3386F-1-102 (and many others) |

| | | | |
|---|---|---|---|
| R30,33 | 2 | 5K + /-10% 3/8'' square top adj. Cermet Pot | Bourns 3386F-1-502 (and many others) |
| R31 | 1 | 2.2K + /5%,carbon **film**, 1/4 w | commonly available |
| R32,63 | 2 | 5.6K + /-5% carbon **film**, 1/4 w | commonly available |
| R34 | 1 | 560 ohm + /-5%,carbon comp,1/4 w | commonly available |
| R35,37,43 | 3 | 15K, + /-5%,carbon comp, 1/4 w | commonly available |
| R36,42 | 2 | 300 ohm, + /-5%,carbon comp,1/4 w | commonly available |
| R39,45 | 2 | 22K, + /-5%,carbon comp, 1/4 w | commonly available |
| R40,46 | 2 | 560K + /-5% carbon **film**, 1/4 w | commonly available |
| R41,47,55 | 3 | 24K + /-5% carbon **film**, 1/4 w | commonly available |
| R48,50 | 2 | 430 ohm, + /-5%,carbon comp,1/4 w | commonly available |
| R49,51 | 2 | 56 ohm, + /-5%, carbon comp, 1/4 w | commonly available |
| R52,53,54 | 3 | 4.7K, + /-5%,carbon **film**, 1/4 w | commonly available |
| R57,61 | 2 | 36K, +- 5%, carbon **film**, 1/4 w | commonly available |
| R58,66 | 2 | 4.3K, + /-5%, carbon **film**, 1/4 w | commonly available |
| R59 | 1 | 500 ohm, + /-10%,3/8'' square, top adj. Cermet pot | Bourns 3386F-1-501 (and many others) |
| R60 | 1 | 1.5K + /-5%, carbon **film**, 1/4 w | commonly available |
| R64,68 | 2 | 3.3K + /-5%, carbon **film**, 1/4 w | commonly available |
| R65 | 1 | 3.6K + /-5%, carbon **film**, 1/4 w | commonly available |
| R67 | 1 | 150 ohm + 5%,carbon comp, 1/4 w | commonly available |
| R69 | 1 | 15K + /-5%, carbon **film**, 1/4 w | commonly available |
| R70,73 | 2 | 160 ohm + /-5%, carbon **film**,1/4w | commonly available |
| R71 | 1 | 750 ohm + /-5%,carbon **film**,1/4 w | commonly available |
| R72 | 1 | 620 ohm + /-5%,carbon **film**,1/4 w | commonly available |
| S1,2,3,4,5 | 5<br>5 | DPDT P-B Switch<br>Buttons for above | Schadow F2U<br>Schadow FG, white |
| T1 | 1 | Transformer, 20 VCT, .6 A, 115 VAC 50-60 Hz | Signal Transformer ST-5-20 |
| (T1)(for 230 VAC system) | | (same but 230 VAC) | (DST-5-20) |
| U1,2 | 2 | Op Amp, video | Signetics NE 5539 |
| U3 | 1 | Op Amp, general purpose | Motorola MC3358P1 |
| U4 | 1 | Shunt Regulator IC | TI TL431CP |
| U5 | 1 | Neg. Regulator, adjustable | Fairchild 79MGU1C<br>Signetics 79GC-U1 |
| U6 | 1 | Op Amp, high speed | Signetics NE5532FE |
| U7 | 1 | Voltage Regulator, T0-220, +8.0 V + /-5% | Any 7808 or 78M08 (T0-220) |
| U8 | 1 | Voltage Regulator, T0-220, -8.0 V + /-5% | Any 7908 or 78M08 (T0-220) |
| - | 1 | Heat sinks for U7, U8 | Thermalloy 6030B-TT<br>Aavid 5630B-TT |
| U9 | 1 | Voltage Regulator, T0-220, -5.2 V + /-5% | National LM320T-5.2<br>Signetics 7905.2 CU |
| U10 | 1 | Balanced Modulator IC | Any MC1496P |

| | | | |
|---|---|---|---|
| VR1 | 1 | 1N5257B Zener (+/-5%) | commonly available |
| Z1 | 1 | Ferrite Bead | Fair-Rite Prod #264300031 |
| - | A/R | Ferrite Bead (use where shown on assembly drawing) | Fair-Rite Prod. #264300031 or 2643001112 (**built-in leads**) |
| - | 1 | PC Board (A2A1) **per figure 17 artwork** | Ramsey Electronics |

**TABLE FIVE**
Demodulator Console A2 (Not including A2A1 or its subassemblies)

| Schematic Part | Quantity | Description | Source |
|---|---|---|---|
| F1 | 1 | Fuse, 3AG, 1/8 A, Slow Blow | commonly available |
| | 1 | Fuseholder, panel, 3AG | Littlefuse 342028 |
| J2,3,4, | 3 | Phono Jack | Switchcraft 3501FP |
| J5 | 1 | Jack, Cinch 2-pin | Cinch 5-302-AB |
| J6 | 1 | Jack, DIN 5-pin | Switchcraft 57GB5F |
| M1 | 1 | Meter, 0-2 mA, 970 ohm | Modutec 1MAS-DMA-002(*) |
| M2 | 1 | Meter, 1-0-1 mA, 970 ohm | Modutec 1MAS-DMA-1U1(*) |
| *-Check with Ramsey Electronics for meters with custom scale plates | | | |
| R1 | 1 | Pot, 25K, +/-10% linear taper | Allen-Bradley JA1N056S-253UA, or JA1N200P-253UA (long shaft) |
| W1 | 1 | Two-wire AC line cord | commonly available |
| - | 1 | Cabinet | PacTec C325, Tan (check with Ramsey Electronics for this cabinet screened for this receiver) |

## Builder's Parts Notes

**REMOTE CONTROL A3**

References:
Schematic - see figure 19
Parts list - see table 6
PC artwork - see figure 20
PC assembly drawing - see figure 21

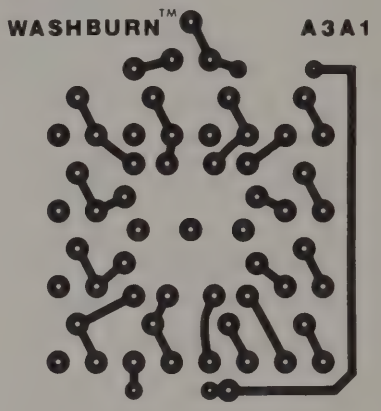
**Theory of Operation**

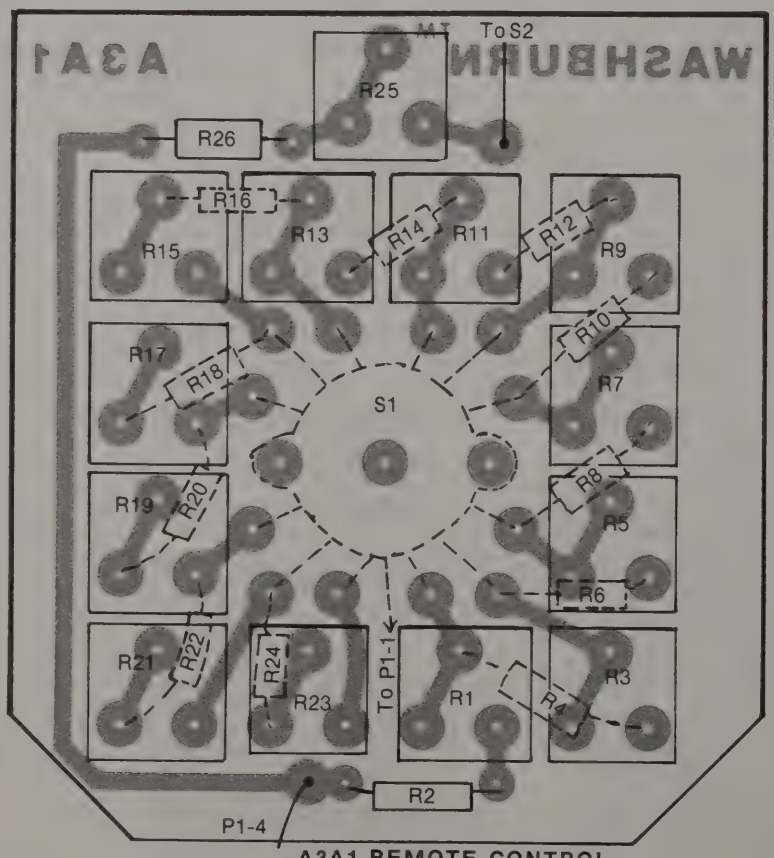
S1 provides selection of 12 different preset and resistor values for control of A2A1 U4 in the remote mode. When S2 is in the Odd/Vertical position it returns 'offset' resistors R1/R2 to ground to provide a 20 MHz offset as previously discussed. In the Even/Horizontal position S2 does double duty by shorting the base of A2A1 Q3 (through the remote cable) ultimately resulting in rotation of the feed by 90° with the action of the rotor control assembly. R27 is the HiFi output volume control whose action on A2A1 U10 was previously described.

**Construction Hints**

The PC board mounts to the rear of switch S1 by removing the tiny nuts (they are size 0-80 if lost!) and the numbered metal plate. Orient the PC board with the copper side towards the switch front bushing, R1 and R23 at the bottom, and the switch 'common' lug at the bottom. Re-install the numbered plate (1 & 12 down) and the nuts. Don't get carried away tightening them; they are **brass** and easily stripped. Doping with nail polish is a **better way** to secure them. Short pieces of buss wire are used from the switch lugs to the PC board and the fixed resistors, R4 through R24, are wrapped from pot lug to pot lug as tie points.

Use a grommet and a secure cable clamp (tape the wire for a snug fit in the 3/16 size) to prevent damage if the cord is yanked. The two shielded pairs in W1 should be used in the pairing arrangement shown (one pair for tuning and one pair for rotor and volume control).




A3A1 REMOTE CONTROL
Figure 21

**Tests**

1) Preset all pots to center, plug into the demod console and select the remote mode, with horizontal polarization. Set pots R1 through R23 in **ascending order** for center tuning on each transponder. If a transponder is dead **on that channel only**, switch to vertical and set the pot on the vertical signal (one # lower, same S1 position). After completing horizontal tuning, switch to vertical and adjust **R25 only** for equal + and - tuning error as you switch through the channels.
2) Now go back and repeat the process, in order, as described in one.
3) Now adjust R1 through R23 in ascending order for equal + and - error on each horizontal/vertical pair (i.e. 1/2 through 23/24). If one transponder of a pair is dead, just set the other for zero error. Plus or minus errors should be 2 MHz or less; typically + /-1 MHz.
4) Any future drifting that appears to equally affect all channel positions can be corrected by adjustment of A2A1 R29 which moves **all tuning positions** an equal number of MHz. As previously noted if you must expose the downconverter to extreme ambients a 250 ohm panel control may be connected in place of A2A1 W1 to allow easy recentering of the AFC range.

**TABLE SIX**
Remote Control A3

| Schematic Part | Quantity | Description | Source |
|---|---|---|---|
| P1 | 1 | Plug, DIN 5-pin | Switchcraft 05GM5M |
| R1 | 1 | 5K + /- 10% 3/8'' square top adj. Cermet pot | Bourns 3386F-1-502 and many others |
| R2 | 1 | 7.5K + /-5%, carbon **film**, 1/4 w | commonly available |
| R3,5,7,9,11,13 | 6 | 1K + /- 10% 3/8'' square top adj., Cermet Pot | Bourns 3386F-1-102 and many others |
| R4 | 1 | 430 ohm + /-5%, carbon **film**, 1/4 w | commonly available |
| R6 | 1 | 560 ohm + /-5%, carbon **film**, 1/4 w | commonly available |
| R8, 16 | 2 | 750 ohm + /-5%, carbon **film**, 1/4 w | commonly available |
| R10 | 1 | 820 ohm + /-5%, carbon **film**, 1/4 w | commonly available |
| R12 | 1 | 910 ohm + /-5%, carbon **film**, 1/4 w | commonly available |
| R14,20 | 2 | 1.1K + /-5%, carbon **film**, 1/4 w | commonly available |
| R15,17,19,21,23 | 5 | 2K + /- 5% 3/8'' square top adj., Cermet pot | Bourns 3386F-1-202 and many others |
| R18 | 1 | 1K + /-5%, carbon **film**, 1/4 w | commonly available |
| R22 | 1 | 1.3K + /-5%, carbon **film**, 1/4 w | commonly available |
| R24 | 1 | 1.5K + /-5%, carbon **film**, 1/4 w | commonly available |
| R25 | 1 | 20K + /- 10% 3/8'' square top adj., Cermet pot | commonly available |
| R26 | 1 | 39K + /-5%, carbon **film**, 1/4 w | commonly available |
| R27 | 1 | Pot, miniature, 250 ohm, + /10%, linear | Allen-Bradley WA2G056S-251UA or GA2G056S-251UA |
| S1 | 1 | Switch, 12 pos., with extended studs for PC board attachment | Ramsey Electronics (Washburn S1) |
| S2 | 1 | SPDT min. toggle switch | JBT JMT 123 or T06-123 |
| W1 | A/R | Cable, 2 shielded pairs, .165 O.D. | Belden 8723 |
| - | 1 | PC board, A3, **per figure 20** artwork | Ramsey Electronics |
| - | 1 | Cabinet | BUD CU-124 |

**SOUND I.F. A2A1A2 or A3**

References:
Schematic - see figure 22
Parts list - see table 7
PC artwork - see figure 23
PC assembly drawing - see figure 24

**Theory of Operation**

A three pole input filter is provided for North America DOMSAT (75 microsecond) deemphasis. It is set up as an 'equiripple phase', 0.05 degree error filter. This provides in excess of 35 dB attenuation of the adjacent subcarrier with a noise band of 200 kHz and linear phase. When ANIK-type audio (CCITT) is expected the filter is reconfigured for 295 kHz at -3 dB with equiripple phase error of 0.5 degrees over a 360 kHz bandwidth and the detector components (L4, L5, C10 and R6) are appropriately changed for the wider bandwidth signal. In this case 25 dB of adjacent channel rejection is provided and relative to the higher modulation index, provides the same performance.

The I.F. IC demodulated output is of the OTA mirror current source type which works against the zero voltage reference of amplifier A2A1 U6A; the supply voltage to the chip is -5.2 and +8 (13.2 volt total). The audio output developed is 500 mV RMS (at U1-6) for full modulation at 400 Hz with a 4.7K audio load at J1-8.

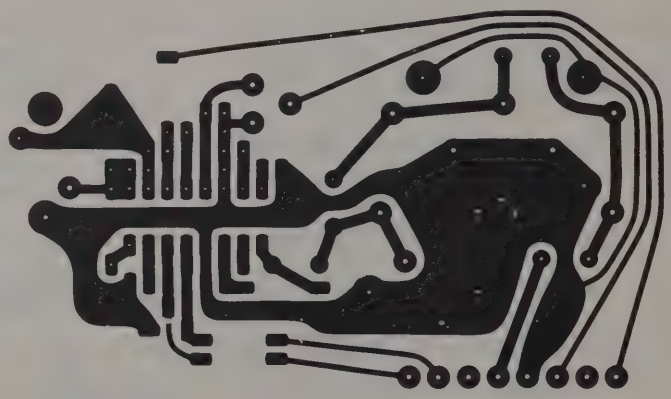
**Construction Hints**

There are no special construction requirements.

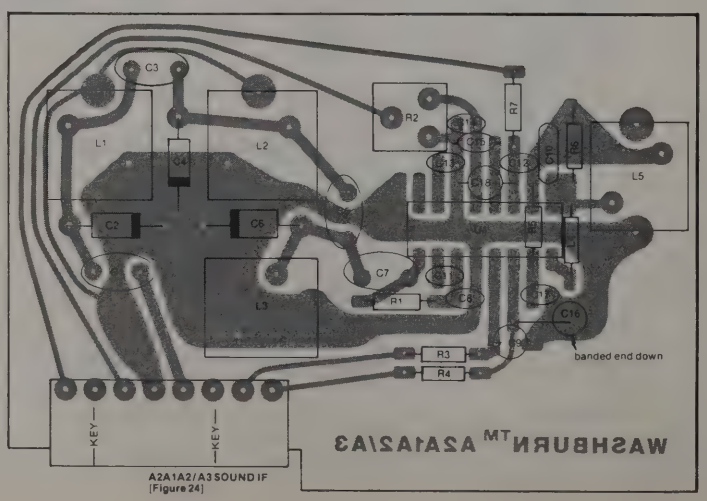
**Tests**

Coil and capacitor values are selected per the schematic chart and parts list. For bench testing a 4.7K resistor may be connected from J1-8 to U1-10, J1-4 is grounded and +13.2V applied at J1-1. Proceed as follows:

1) Connect a 50 ohm signal generator at J1-5 (shield to J1-4) at the appropriate center frequency (i.e. 6.8, 6.2, etc. MHz).
2) Set R2 at midrange and connect a DC voltmeter from J1-3 to ground.
3) Increase the signal generator level until a voltmeter reading of .7V is obtained (do not exceed 100 mV input with the signal generator).
4) Tune L1, L2 and L3 for max, decreasing the signal generator output to **maintain** .7 VDC.
5) Short out L2 using a 10 ohm carbon comp resistor and increase the signal level from the generator until you read slightly over .1 VDC on the meter.
6) Tune L1 and L3 for maximum meter reading.
7) Remove the 10 ohm resistor, reduce the signal generator output for a reading of approximately .7 VDC and now peak L2.
8) Connect the DC voltmeter across the 4.7K

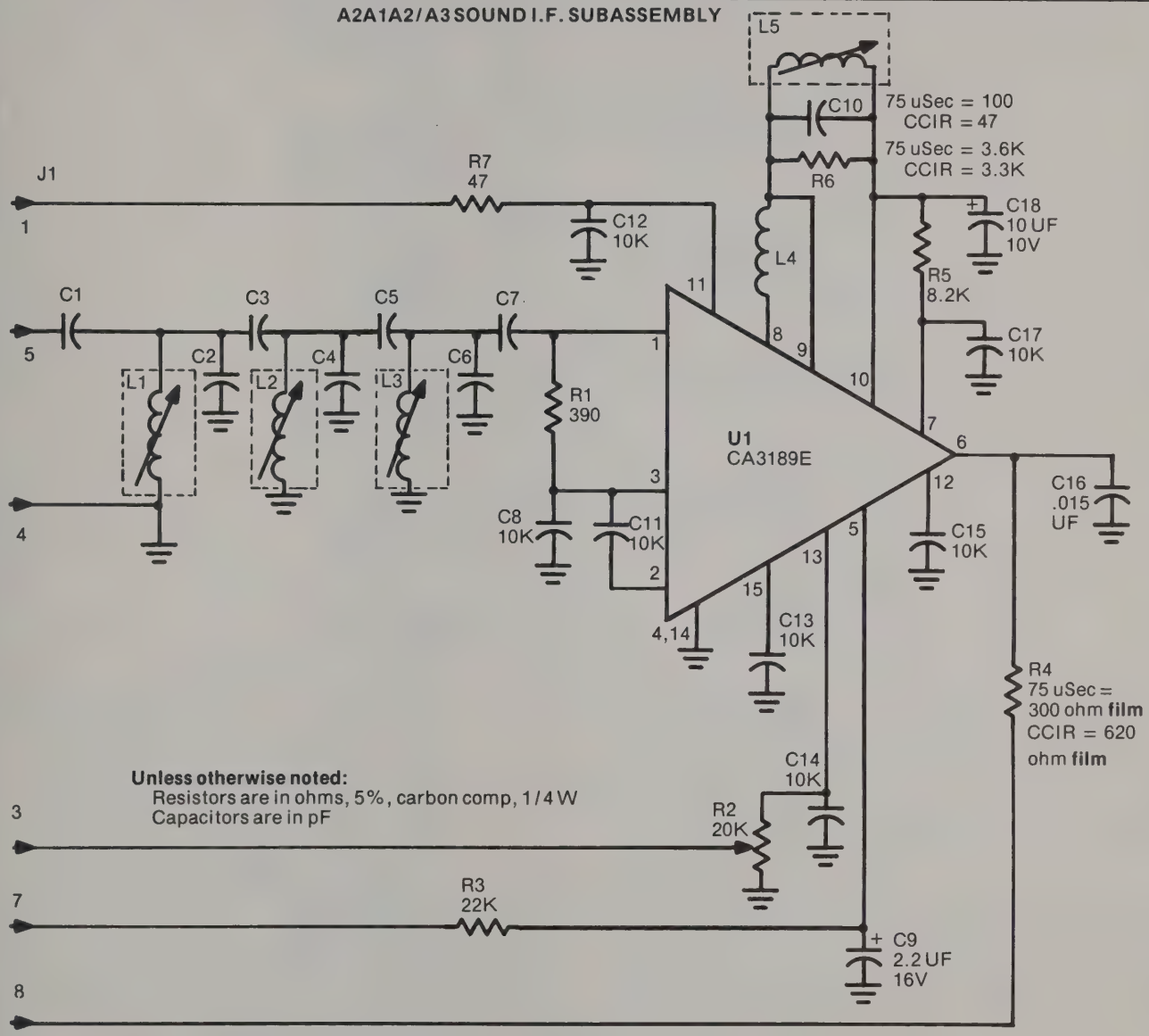


**A2A1A2/A3 SOUND IF**



audio load resistor. Adjust L5 for zero volts. If possible verify correct tuning by applying suitable frequency modulation (FM) to the signal generator and observe the undistorted output on a scope.

Install the module in the receiver and adjust sound I.F. R2 so that the LED for that sound I.F. is **off** when a carrier is not present and on when the carrier is present (note the two thresholds and split the difference with R2).




| | CENTER FREQ. | C1 | C2 | C3 | C4 | C5 | C6 | C7 | L4 | L5 |
|---|---|---|---|---|---|---|---|---|---|---|
| 75 uSec 75 kHz Δ F U.S.A. | 5.6 MHz | 150 | 430 | 22 | 560 | 15 | 560 | 43 | 39 uH | 1 |
| | 6.2 MHz | 110 | 390 | 15 | 470 | 10 | 470 | 33 | 39 uH | 2 |
| | 6.8 MHz | 110 | 390 | 15 | 470 | 10 | 470 | 33 | 33 uH | 2 |
| CCITT 160 kHz Δ F (ANIK) | 7.4 MHz | 82 | 330 | 10 | 390 | 6.8 | 390 | 27 | 33 uH | 3 |
| | 5.41 MHz | 180 | 430 | 39 | 600 | 22 | 600 | 51 | 47 uH | 4 |
| | 6.17 MHz | 120 | 360 | 25 | 470 | 15 | 470 | 33 | 39 uH | 5 |
| | 6.80 MHz | 120 | 360 | 25 | 470 | 15 | 470 | 33 | 33 uH | 5 |

Figure 22

**TABLE SEVEN**
Sound I.F. A2A1A2/A3

| Schematic Part | Quantity | Description | Source |
|---|---|---|---|
| C1 | 1 | Dipped mica, CM05 size, value per schematic chart | MIL # CM05<br>82pF (EDB820J03)<br>110pF (FD111J03)<br>120pF (FD121J03)<br>150pF (FD151J03)<br>180pF (FD181J03) |
| C½ | 1 | Polystyrene 160 WV, value per schematic chart | Mallory<br>330pF (SXM333)<br>360pF (SXM336)<br>390pF (SXM339)<br>430pF (SXM343) |
| C3 | 1 | Disc ceramic, + /-5% value per schematic chart | Sprague 10TCC-<br>10pF (Q10)<br>15pF (Q15)<br>22pF (Q22)<br>25pF (Q25)<br>39pF (Q39) |
| C4,6 | 2 | Polystyrene 160 WV, value per schematic chart | Mallory<br>390pF (SXM339)<br>470pF (SXM347)<br>560pF (SXM356)<br>600pF (SXM360) |
| C5 | 1 | Disc ceramic, + /-5% value per schematic chart | Sprague 10-TCC<br>6.8pF (V68)<br>10pF (Q10)<br>15pF (Q15)<br>22pF (Q22) |
| C7 | 1 | Disc ceramic, + /-5%, value per schematic chart | Sprague 10TCC-<br>27pF (Q27)<br>33pF (Q33) |
| | | Dipped mica CM05 size, value per schematic chart | MIL #CM05-<br>43pF (ED430J03)<br>51pF (ED510J03) |
| C8,11,12,13,14,15,17 | 7 | .01UF + /-20% 'Redcap' 651 type | Erie 8121-050-651-103M<br>(others cross reference) |
| C9 | 1 | 2.2UF + /-20%, 16V dipped tantalum | Sprague 199D225X0016AB1<br>Kemet T390A225M016AS |
| C10 | 1 | Dipped Mica, CM05 size, value per schematic | MIL # CM05-<br>47 pF (ED470J03)<br>100pF (FD101J03) |
| C16 | 1 | .015UF + /-5% Mylar | CDE 1S15 + /-5% |
| C18 | 1 | 1OUF + /-20% 10V dipped tantalum | Sprague 199D106X0010BB1<br>Kemet T390B106M010AS |
| J1 | 1 | 8 pin receptacle | Molex 09-52-3081 |
| - | 2 | Keys for above (pins 2 & 6) | Molex 15-04-0219 |
| L1,2,3 | 3 | Coil 1.5 uH nom., 1/2'' x10-32 'E' Core | Coilcraft 112-23-1/2T-1/2E-Pos 1 |
| - | 3 | Shield for above, 9/16'' sq., 7/8'' high, .250 hole in top | Ramsey Electronics |
| L4 | 1 | .25 x .095 molded choke, + /-10% value per schematic chart | Delevan 1025-<br>33uH (56)<br>39uH (58)<br>47uH (60) |
| L5 | 1 | Coil form .225 dia. x 1'' high, 2 eyelet lugs, 1/2'' 'E' core | Coilcraft 10-32 'T-Form' w/ 1/2'' 'E' core and Z hollow lugs (opposed) high from mounting plane |

| | | | |
|---|---|---|---|
| | | **Winding Instructions:** | **Seal all windings with 'Q-Dope' or clear nail polish** |
| | | **L5-1** 63-1/2 T #30 (close-wound) or #32 (space to .74 long) | |
| | | **L5-2** 60-1/2 T #29 (close-wound) or #30 (space to .74 long) | |
| | | **L5-3** 55-1/2 T #28 (close-wound) or #30 (space to .75 long) | |
| | | **L5-4** 107-1/2 T #34(close-wound) or #36 (space to .65 long) | |
| | | **L5-5** 93-1/2 T #33 (close-wound) or #34 (space to .73 long) | |
| - | 1 | Shield for above, 9/16'' square x 7/8'' high, .250 hole in top (tape O.D. of coil form for snug fit in hole) | Ramsey Electronics |
| R1 | 1 | 390 ohm + /-5%,carbon comp,1/4 w | commonly available |
| R2 | 1 | 20K + /-10% 3/8'' sq. top adj., Cermet pot | Bourns 3386F-1-203 and many others |
| R3 | 1 | 22K + /-5%,carbon comp, 1/4 w | commonly available |
| R4 | 1 | Value per schematic, + /-5% carbon **film**, 1/4 w | commonly available |
| R5 | 1 | 8.2K + /-5%,carbon comp, 1/4 w | commonly available |
| R6 | 1 | Value per schematic, + /-5% carbon comp, 1/4 w | commonly available |
| R7 | 1 | 47 ohm + /-5%,carbon comp, 1/4 w | commonly available |
| U1 | 1 | IC limiter, detector | RCA CA3189E |
| - | 1 | PC board **per figure 23 artwork** | Ramsey Electronics |

**ROTOR CONTROL A4**

References:
Schematic - see figure 25
Parts list - see tables 8 and 9
PC artwork - see figure 26
PC assembly drawing - see figure 27

**Theory of Operation**

An Alliance C225 type (antenna) rotor **motor** was selected because it is a powerful, flexible-in-mounting, inexpensive device that provides a position feed back pot. When used with an Alliance thermal protected transformer and the original type capacitor it is highly resistant to burn-out when your two-year-old starts playing with the odd/even switch(!).

Position sensing is by means of a bridge with R6 and R7 on one side and R4, R1, R2 and R3 and the rotor pot on the other. 90 degree rotation is induced by shorting out R2/R3 with K1 causing a new 'balance point' to appear 90 degrees away. R1 and R2 provide approximately + /-15 degrees of variation around each of these two balance points with R1 moving both and R2 controlling the size of the approximately 90 degree increment. The 'sense' of K1 may be changed with a jumper, depending upon whether a move from vertical to horizontal will be CW (clockwise) or CCW (counter clockwise) on your antenna system.

U1A amplifies the bridge output with C1 providing some filtering so that noisey rotor pot contact will not fool the control circuit while the rotor is turning.

U1B acts as a Schmidt trigger and decides the direction of rotation necessary to correct the bridge error, with K2 effecting the motor direction reversal.

U1C and D act as double ended limit detectors with hysterisis, turning on the rotor whenever the error exceeds -30 dB crosspole nulling (assuming a SIN null shape) and stops the rotor when error is less than -40 dB crosspole (same null assumption) with Q1 and K3 switching the actual rotor input power.

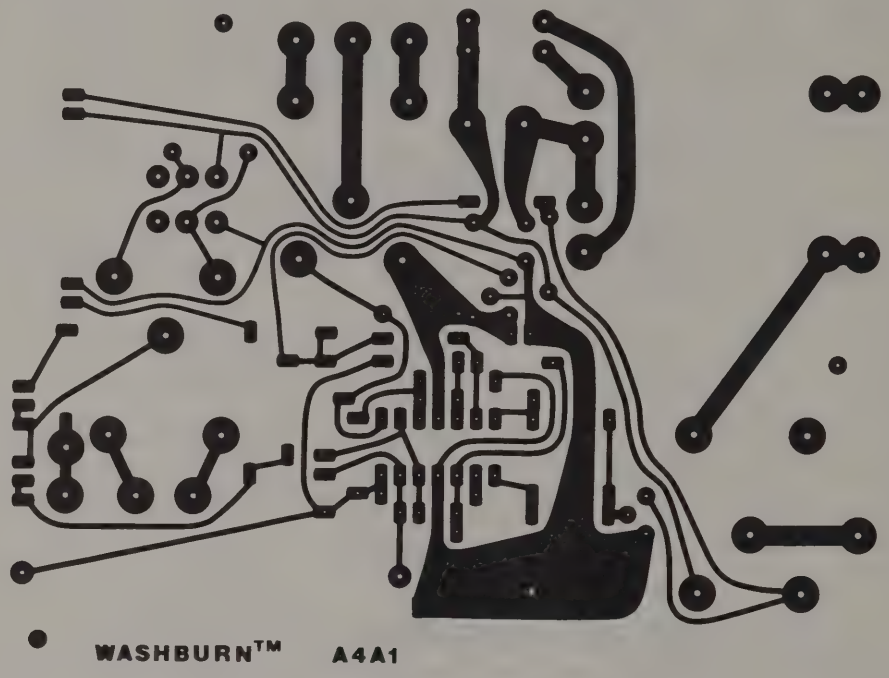
The power supply fed from R1 provides +13V for the op amps and relays with U2 providing a regulated +5V for the position sensing bridge. Test switch S1 allows local control of K1 for null adjustments.

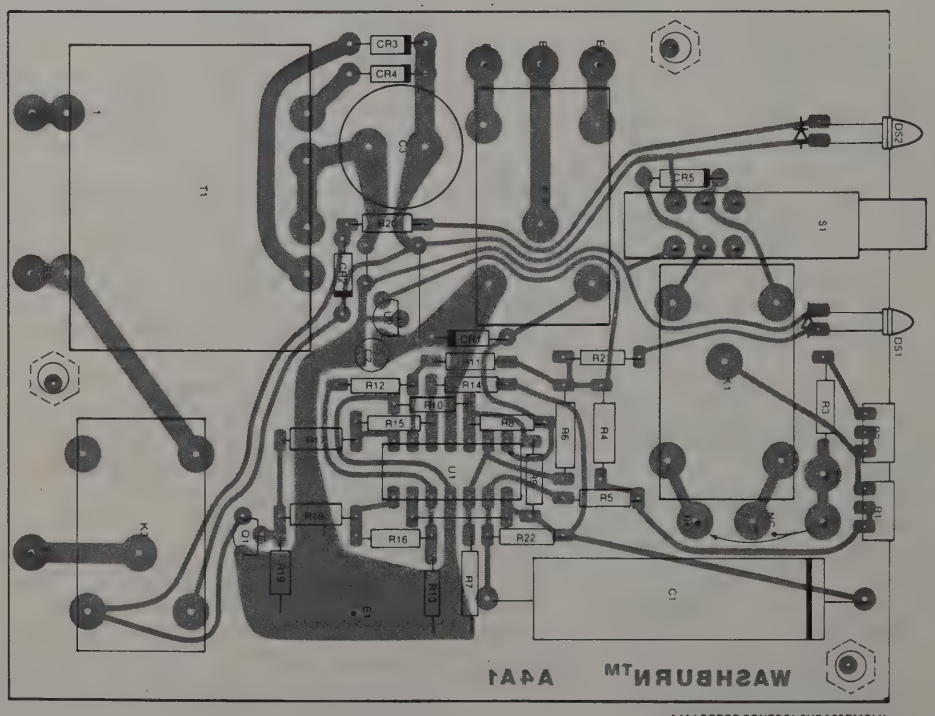
**Construction Hints**

The rotor should be mounted with the plastic rain deflector at the higher end. For prime focus feeds this will generally mean mounting the rotor ahead of the 'focus plate' with a clearance hole for the center shaft (a short piece of pipe welded to the plate or mounted with a pipe flange will allow rotor mounting in this fashion with no rotor mounting

modifications). At the center shaft, readily available 1'' trade size, schedule 40 aluminum pipe (1.315'' OD) will center perfectly if .040 aluminum strips 1/2'' wide are bent into a C or U shape and used to increase the pipe diameter at the points where it is clamped by the rotor.

Before the rotor is mounted, internal clearances can be tightened up for a solid LNA and horn positioning by using washers on the worm gear drive shaft to eliminate end play (which produces rotation backlash) and shim stock under the main shaft bearing liners to eliminate radial 'looseness'. Lubing of all gears, bearings and the feedback pot with Molykote G paste will insure long life (this

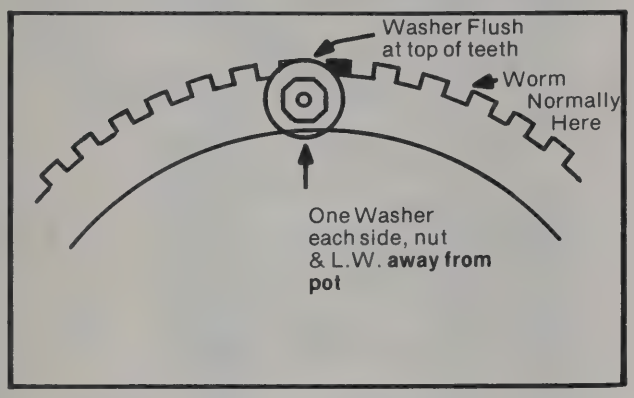



A4A1 ROTOR CONTROL SUBASSEMBLY
Figure 27

stuff bonds to the metal surfaces; don't use excessive amounts as no extra good will be done and low temperature sluggishness may result).

If feed rotation in excess of 110 degrees (90 plus + /-10 variance at either end) might damage your cables and/or LNA, positive mechanical protection can be provided by using the internal rotor stop at the CW end (as viewed from the top) and installing a new CCW stop as follows:




1)Move the rotor CCW until the pot is providing **168 ohm resistance**; this is as far as the rotor control can take it with any normal pot adjustment.
2)Physically mark **the** tooth on the ring gear that is **about** to enter the worm on the side one sees when opening the motor case.
3)Remove the center shaft being careful not to damage the pot or its wiper and **drill** the worm gear for a #8 screw, 2 washers, lockwasher and nut as shown here.
4)Reassemble taking care that you are not trapped on the wrong side of the new stop (!) and that the pot wiper is riding properly **outside** the pot winding.

There are no special construction considerations for the rotor control assembly.

**Tests**

Decide whether, with your antenna, the feed will turn **CW** or **CCW** viewed from the top (rain shield) of the rotor to move from **vertical** to **horizontal**. K1 will be energized in the vertical mode and the rotor will be **CW** with R2 and R3 shorted out so:

| **If:** | **Is:** | **Jumper to:** | **R1 is:** | **R2 is:** |
|---|---|---|---|---|
| V to H | CW | K1-NC | Horz. (Vert.null) | Vert. (Horz.null) |
| V to H | CCW | K1-NO | Vert. (Horz.null) | Horz. (Vert.null) |

Connect the appropriate jumper and proceed.

Connect the rotor and rotor control using the approximate length of cable expected in the final installation (not critical as cable resistance is minor). With no connection to TB1-6 and 7 and with R1 and R2 centered, pushing and releasing (2nd push) should cause the rotor to move between the two positions very close to 90 degrees apart. If the rotor wants to run in the opposite (wrong) direction reverse the wires on TB1-2 and 3. If all is now OK reverse the wires coming **from** A4A1 E2 and E3 and **return** the TB1 wires to their proper (original) order. At the bottom of the rotor mark where some prominent feature of the center shaft points in the two positions, so that you can remember which position the feed horn will be in initially. Unless your feed behaves strangely you can achieve very good results by leaving the **Delta** pot (R2) centered (R2 + R3 = 130 ohms) making a single null adjustment using the common pot R1. The following procedure has been used with good success:

1)Tune to a transponder known to be **completely off** (i.e. transponder 4 on F1) with AFC switched off. Preset rotor controls R1 and R2 at their centers.
2)Disconnect the wire at TB1-7 (do **not** disconnect TB1-**6** as it is +12V and might short to ground). Test switch S1 will now give you vertical when pressed and horizontal when released (i.e. 2nd push).
3)Switch S1 to vertical (in) and mechanically adjust your feed rotor center shaft for a fair null (**minimum** signal from adjacent transponders 3 and 5) and then retighten the rotor clamps.
4)Find the center of the null by finding the positions where the signal strength begins to increase above the noise floor; then split the difference. Do this as a **series** of **small** adjustments using DS2 (amber) to tell you when the rotor has completed the last increment, before adjusting again.

If your antenna mount is not a perfect polar mount and you do move from one bird to another from time to time, you may wish to find a mechanical feed position that allows proper null on all ortho birds (24 channel) to be found in the range of R1 (the V/H shift will always be 90° from the position set by R1).

**VTR INTERFACE NOTES**

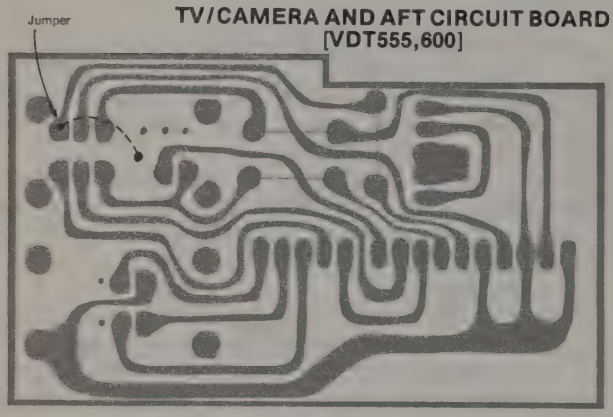
Washburn started out originally to include an LM1889 type modulator (see **Howard Terminal Manual** from **STT** for complete LM1889 schematic) but after studying the Service Manual for the RCA (Matsushita/Panasonic manufacture) VTRs the decision was made to approach the local RF remodulation in a different manner. The typical VTR achieves a remarkably high quality modulated signal with features that include:

1)True crystal control on channel frequency 3 or 4 (NTSC version);
2)A fully independent sound subcarrier generator that allows full sound subcarrier level as opposed to the typical LM1889 device which produces sound/video interaction and distortion with sound subcarrier levels above approximately -20 dB (relative to the visual carrier);

3)Sync clamping at the modulator, preceded by video level AGC and a high quality video baseband filter (which rejects 6.2 and 6.8 MHz or actually everything above approximately 5.5 MHz).

These features coupled with the obvious advantage of being able to record by reaching over and pressing two buttons (since the video is always going through the machine) settled the issue of whether or not to include a modulator.

**Note:** For those who do wish to include a modulator, the baseband outputs from the Washburn receiver are readily adaptable to this use provided a video baseband filter that rolls off sharply between 5 and 5.5 MHz is included in the outboard baseband tie-line to the modulator is added.)



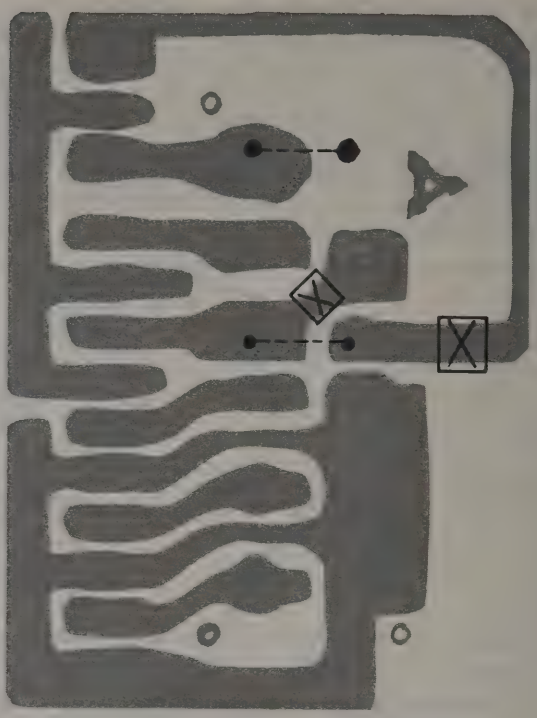

**TV/CAMERA AND AFT CIRCUIT BOARD [VDT555,600]**

VCT 400, 400X, VDT 350

**TV/CAMERA INPUT**

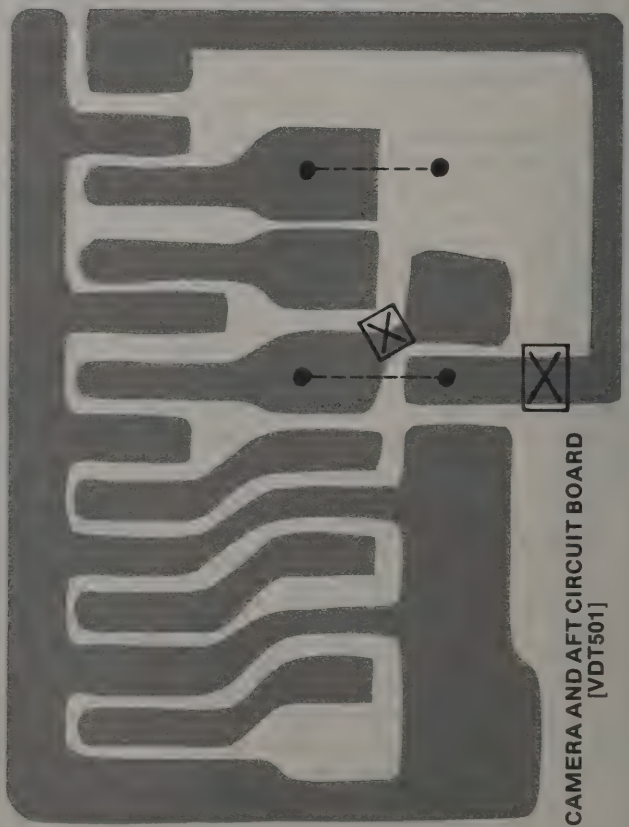
One wrinkle encountered by Washburn was that although the RCA VTR schematic **shows** audio from the camera inputs (used for the receiver) reaching the modulator when not recording the traces were **not** in fact on the PC board. A jumper is added to correct for this 'oversight'. Jumper locations for all late model RCAs are shown here and most Masushita manufactured units should be identical to very similar (including GE, Sylvania, Magnavox, Panasonic, Philco and Quasar among others).

For this group of recorders the audio level should be about correct with the VCR audio pot



**Cut at two 'X' marks, add dotted jumpers** VCT 201,300,310, VDT 201

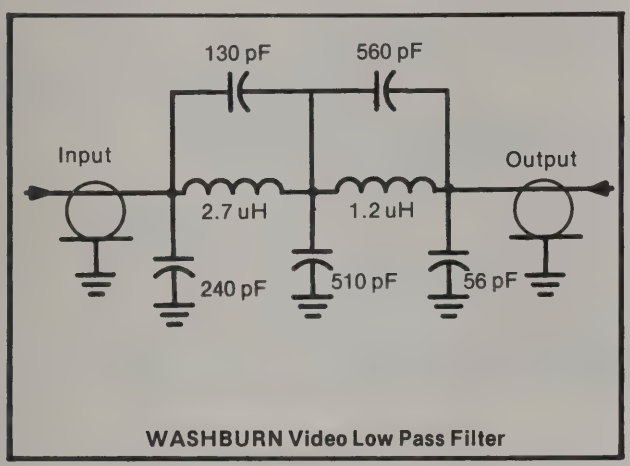
**TV/CAMERA INPUT**



**TV/CAMERA AND AFT CIRCUIT BOARD [VDT501]**

**Cut at 'X' and add dotted jumpers**

(A2A1 R59) at center. Proper adjustment merely involves turning this pot until the audio level apparent from the receiver is the same as that coming from normal off-air television channels (this avoids bothersome large differences in apparent audio level when switching from local to satellite service). The audio level can be readily changed; if too low for your situation, lower the value of A2A1 R58 (470 ohm minimum). C30 could (also) be changed to a non-polar type if R58 is less than 2.2K.




**WASHBURN Video Low Pass Filter**

If you wish to drive a separate (LM1889 or other) modulator or your VCR will not tolerate the audio subcarrier inputs the low pass filter shown here can be constructed and placed inside of a Minibox.

The chokes in the lowpass shown are Delevan 1537 and the capacitors are CM05/CM06 dipped micas. The ripple of this low pass filter is 0.5 dB P-P from DC to 4.9 MHz. The group delay is flat from DC to 4.2 MHz + /-50 nanoseconds. The 6.2 MHz subcarrier falls into a design notch while the 6.8 MHz subcarrier is more than 21 dB down. This should be adequate attenuation since the deep notch surrounding the 6.2 MHz subcarrier point effectively kills any chances of a 600 kHz beat being generated in later circuitry.

**Note:** The presence of 5.5 MHz often-digital-modulated subcarrier signals on **some** of the WESTAR and SATCOM FII transponders may result in an undetermined amount of crossmod with this lowpass filter. The use of these 5.5 MHz subcarriers is still so new (and they are largely being utilized for test purposes) that their impact (long term) on receiver design in practical receiver applications is not yet certain. As (and if) they proliferate the subject will receive treatment in (Coop's) **Satellite Digest** where both the problem (if there is one) and the solutions will be presented.

**TABLE EIGHT**
Rotor Control A4A1

| Schematic Part | Quantity | Description | Source |
|---|---|---|---|
| C1 | 1 | 1.OUF + /-10%, 50V, mylar | CDE 05W1 |
| C2 | 1 | 6.8UF + /-20%, 16V, dipped tantalum | Sprague 199D685X0016BB1<br>Kemet T390B685M016AS |
| C3 | 1 | 1000UF, 16V, electrolytic | Sprague 503D108F016QE |
| CR1,2,3,4,5 | 5 | Rectifier, 1A, 100 PIV | 1N4002,4003,4004,4005,4006,4007 |
| DS1 | 1 | LED, green | H-P 5082-4955 |
| DS2 | 1 | LED, amber | H-P 5082-4555 |
| K1,2,3 | 3 | Relay, 12 VDC, 1400 ohm coil, SPDT | Guardian 1345-1C-12D<br>Sigma 49RE1C2VF-12DC-SC0 |
| Q1 | 1 | 2N4124 | commonly available |
| R1,2 | 2 | 50 ohm, + /-10%, 3/8'' square top adj., Cermet pot | Bourns 3386F-1-500 and many others |
| R3 | 1 | 105 ohm + /-1% metal **film** | any RN55D |
| R4 | 1 | 169 ohm + /-1% metal **film** | any RN55D |
| R5 | 1 | 1.2K + /-5%, carbon **film**, 1/4 w | commonly available |
| R6,7 | 2 | 1.21K + /-1% metal **film** | any RN55D |
| R8 | 1 | 20K + /-5%, carbon **film**, 1/4 w | commonly available |
| R9 | 1 | 360 ohm + /-5%, carbon **film**, 1/4 w | commonly available |
| R10 | 1 | 12K + /-5%, carbon **film**, 1/4 w | commonly available |

| | | | |
|---|---|---|---|
| R11,12 | 2 | 1.1K + /-5%,carbon **film**, 1/4w | commonly available |
| R13 | 1 | 1K + /-5%,carbon **film**, 1/4 w | commonly available |
| R14 | 1 | 680 ohm + /-5%, carbon **film**, 1/4 w | commonly available |
| R15,16 | 2 | 10K + /-5% carbon **film**, 1/4 w | commonly available |
| R17,18 | 2 | 10K + /-5%,carbon comp, 1/4 w | commonly available |
| R19 | 1 | 4.7K + /-5%,carbon comp, 1/4 w | commonly available |
| R20 | 1 | 1.1K + /-5%,carbon comp, 1/4 w | commonly available |
| R21 | 1 | 270 ohm + /-5%,carbon comp, 1/4 w | commonly available |
| R22 | 1 | 33K + /-5%,carbon **film**, 1/4 w | commonly available |
| S1 | 1 | DPDT P-B switch | Shadow F2U |
| - | 1 | Button for above | Shadow FG, red |
| T1 | 1 | Transformer, 20VCT, .30 A, 115 VAC 50/60 Mz | Signal Transformer ST-4-20 |
| U1 | 1 | Quad Op Amp | Any LM324 (Dip) |
| U2 | 1 | Voltage regulator,T0-92,5V + /-5% | Any 78L05 + /-5% (T0-92) |
| - | 1 | PC board, A4A1, **per figure 26 artwork** | Ramsey Electronics |

**TABLE NINE**

Rotor Control Assembly A4

| Schematic Part | Quantity | Description | Source |
|---|---|---|---|
| C4 | 1 | 210-290 UF, 35 VAC | Alliance 18061A<br>Mallory ST290P |
| F1 | 1 | Fuse, 3AG, 1A, normal blow | commonly available |
| - | 1 | Fuseholder, panel, 3AG | Alliance 18764-R |
| M1 | 1 | Rotor motor, as used in Alliance C225A | Alliance 9129R (check with Ramsey Electronics on availability of units with slack removed and limit stops installed) |
| T2 | 1 | Power transformer | Alliance 18764-R |
| T3 | 1 | 115/230VAC 50/60 Hz autotransformer, 100 VA | Signal Transformer 110-0F |
| TB1 | 1 | terminal strip, 7 screw | Cinch 17-7 |
| W1 | 1 | AC line cord, 2 wire | commonly available |
| - | A/R | A4 to rotor wire, 5 conductor #22 (up to 75' run), or,<br>5 conductor #20 (up to 125' run) | Belden 8445<br>Belden 9445 |
| - | A/R | A4 to demodulator console wire, 2 cond. #22 | Belden 8442 |

**Builder's Parts Notes / Rotor Control Assembly**

**ERRATA and UPDATES**

Any project as thorough as the Washburn High Performance TVRO Receiver is bound to have a few 'gremlins' slip in from time to time. Additionally, as additions and updatings come along you are (as a purchaser of this manual) entitled to be kept advised of these changes.

While this material will appear in (Coop's) **SATELLITE DIGEST** you may wish to have this data as it is released in errata sheets as well. Simply prepare a business size envelope (#10 standard) with 15 cents US postage on it **addressed to yourself**, mark in the lower left hand corner 'WASHBURN ERRATA' and send it to:

**Satellite Television Technology, P. O. Box G, Arcadia, OK 73007.**

If (or as) ERRATA sheets are issued, you will be mailed the sheet(s) in your envelope provided. **Receipt** of one ERRATA sheet will be your signal to send along a **new** self-addressed, stamped envelope.

# WASHBURN ENGINEERING CONSULTATION FROM

While this manual is intended to be a complete guide to duplication of the Washburn High Performance TVRO Receiver there are likely to be questions which occur to you which you will not find answers for in this manual. Clyde Washburn has agreed to make himself available for **mail consulting** (i.e. all questions are handled by mail both ways) for a one-time fee of $25. By completing the form below you will be placed into Mr. Washburn's consulting file and will be entitled to seek his advice and recommendations on any questions you may have regarding duplication of this receiver; whether from circuit boards and parts you obtain on your own, or for parts/kits you obtain directly from Ramsey Electronics.

If you would like to have the direct assistance of engineer/designer Clyde Washburn with your own Washburn Receiver project, you may complete the form below and send it to Mr. Washburn's address as given.

**Attention: Mr. Clyde Washburn, Jr., 195 Thayer Road, Fairport, NY 14550**

I wish to avail myself of your consulting service as outlined in the Washburn High Performance TVRO Receiver Manual and am enclosing my check made out to you for $25. I understand that I am entitled to unlimited requests for assistance in **duplication** of your receiver (requests for assistance in designing or debugging modified circuits are not covered by this agreement) as long as those requests are made directly to you in the mail.

Accordingly, please place my name and address in your files, as follows:

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Address_____

City_____ State_____ Zip_____

(Signed):_____ Date_____

For Washburn Use:_____

1)Date Received_____ 2)File #_____

3)Assistance History_____

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**Rochester, NY**
**U.S.A. 14610** **(716-271-6487)**

A1A1 DOWNCONVERTER

Unless otherwise noted:
Resistors are in ohms, 5%, carbon comp, 1/4 watt
Capacitors are in pF

INPUT from LNA
J5
W1
P2
See table for Max Input
U1
R
X
L
-7.1 dB
J1
J2
Z7
CR1 MCL 1304
To C8
C1 470
C2 470
Z1
Z2
Z2
U3 VTO
2.88-3.38 GHz
VT
+15
U2
+15
+6 dB
FL1
54MHz at -3 dB
820 MHz CF
1.0 dB I.L.
To A1 +15V (185 mA)
Z6
C4 470
Z3
+15
+5dB
U4
+18.1 dB
C5 18
U5
R/X
L
2,4,5
C6 1.2
Approx. +16 dBm
P1 51
890 MHz Freq. check
J3
Z4
R1 470
U6 VTO 80 MHz
+15
Vt
To A1 +47V approx. 8 mA
To CR2
C8 470
R11 4.7K
Approx. 28V
R2 20K film
C9 1.5 uF 50V
R3 10K film
C
E
B
U7
A1A1A1 Reg. Sub Assy
R4 1.8K film
CR2 1N4152
R9 see table
L1 .51 nH
C22 470
Z6
+8.6 V
C20 1000
R10 560
L7
Shield Cover
+8.6V
R7 150
C19 1000
C7 18
R5 24
Output to demod console
J4
+32.5
C21 1000
U9
C17 18
+18.9 dB
L6
Low Pass
High Notch L5
C16 22
C15 22
C14 33
C13 22
Mid Pass L4
C12 10
C10 22
High Pass L2
L3
Low Notch
C11 22
+19.9 dB
U8
C18 1000
+7.5 dB
R6 120
Low Gain Option
70 MHz I.F. Filter
30 MHz at -3 dB,
approx. 1 dB I.L.

Figure 7

A2A1A1 PLL DEMOD ASSEMBLY

-12V Approx. 145 mA
C17 470
Z4
C18 2.2uF 16V
NOTE 3
U4
-5.2V
C19 1.0 uF 25V
Z5
R7 6.8K
W1
1.48V set*
Z7
Sig. Str. Approx. 100-200 mV
C16 470
Z3
C3 470
VT from A2A1
Z1
C2 1000
L1
From down-converter -28 dBm min
J1
C1 1000
R1 50
Gain Set
C4 10K
IN
C3 10K
C7 10K
C6 10K
C5 10K
U1 SL550D
GND
AGC
AGC
OUT
C8 10K
C9 10K
C13 470
R2 750
approx. 57 mV
NOTE 1
Q2 2N5089
R8 1K
C20 470
L2 .39 uH
R11 130
C22 10K
R12 82
U5A
R13 270
Z6
680 mV P-P* 10K
TP3
C31
+6V
R18 500
R19 1.2K film
R20 120 film
approx. + .26V
Q3 2N4258
C23 10K
R14 270
Approx. 1.29V
R17 9.1K
R15 270
R16 1K
U5B
U5C
C21 10K
CR1
C25 10K
TP2
R6 1.3K
TP1 +
C15 220uF 10V
C24 10K
R5 510K
Q1 2N 4126
Approx. .5 mA
C14 1000
R4 820 film
680* mV set
R3 1K
U2 SL 1613C
Gnd
Bias
In
Gnd
V+
Out
Det
C33 10K
C32 1-10
U6 SP1658
Vee
Vcx
BF
IF
Vcc
Vcc
Q
Q
TP7
TP6 70* MHz
C26 12
TP4 +1.48V WRT-TP5
R21 100 film
Q4 2N4258
Q5 2N4258
Z8
C27 91
TP5 - (-5.2V)
C28 10K
L3 3.3 uH
Note 2 Q6 2N4124
R22 300 film
Note 2 Q7 2N4401
R23 30 film
L4 2.2 uH
C29 220
Z10
Z9
R9 500
C30 10K
Output Zero
R10 680 film
W2
P1
189 mV P-P video
+12 V Approx. 55 mA
C12 470
Z2
C11 1.0 uF 25V
NOTE 3
U3
+6V
C10 10K
Shield Box

*Under test conditions only
1) Epoxy flat to U1 for thermal tracking
2) Epoxy Q6 & Q7 flat to flat for thermal tracking
3) Heat sink to shield, U4 requires mica insulator & shoulder washer

Unless otherwise noted:
Resistors are in ohms, 5%, carbon composition, 1/4w
Capacitors are in pF

Figure 13

A2A1 PROCESSING ASSEMBLY

75 ohm Video Out 1V P-P E1 E2

115 VAC E10 E11

+12V to A2A1A1 E16

+12V E12 V/H SW E13

POWER SUPPLY

Q3 2N4124

CR8 1N4004

E14 V/H

E15 Grd

Video Gain

C3 200 pF

R3 82 film

R4 200

R5

R7 820* film

2-8.2K film

R6

C2 3.0 pF

Video Processing

C8 2.7 pF

R13 1K* film

+8V

C1 33 pF

C4 .01

R9 910 film*

approx. 2V P-P

R10 82

C7 30 pF

C9 .01

C11 1.5 25V

C12 22 10V

R16 75 film

R14 8.2K

C14 330 10V

J1 Video Input Approx. 189 mV P-P

R2 51

U1 NE5539

R8 470

R11 820 film

U2 NE5539

C10 .02

-8V

L1 0.56 uH

R15 24

R17 130 film

R18 180 film 1/2 w

C13 22 10V

Z1

Q2 2N2219

R1 75

R19 7.5K film

C5 .01

C6 .01

Q1 J112

R12 100K

S2 Vid.Pol.

CR1 1N4448

(4) 1N4004

Approx. 220 mA

T1

CR4 CR5

+12V

C20 4700 16V

C22 1.0 25V

U7 7808 w/heat sink

R35 15K

R34 560

CR9 1N 4004

DS1 On

+8V (supply)

20 VCT

C21 4700 16V

CR6 CR7

Approx. 340 mA

-12V

U8 7908 w/heat sink

C24 1.0 25V

CR10 1N 4004

-8V (supply)

S1 Pwr

E17 to A2A1A1 -12V

C23 2.2 16V

RMT RT Low E5

Local Rt Low E6

RMT Rt. High E7

Local Rt Hi E8

Local/Rmt S3B

S3A

R32 5.6K film

R33 5K Local Cal.

Vt to A2A1A1 C3 E9

R20 120K film

C15 .0022

R24 120K film

S4A

C17 .01

R27* 270K

VR1 1N5257B

-1.25V TP1

U4

R30 5K

U5 79MG

R31 2.2K

-1.25 Adj.

C19 2.2 16V

C16 .01

U3A MC3358

U3B

R23 27K film

R22 27K

R21 6.8K

R26* 5.6K

R25 N/U

S4B AFC

R28 1.3K film

CR3

CR2 IN4152

W1

R29 1K

C18 1.0 25V

E3 E4

Center Tuning Meter 470 ohm 1-0-1 mA.

Tuning & AFC

Audio Processing

R67 150

C31 47 10V

R65 3.6K

R66 4.3K film

C33 220 16V

Q8 2N4124

R64 3.3K

U10 MC1496

R68 3.3K film

C34 6.8 25V

E18 Hi-Fi Audio

C32 220 16V

C35 100 10V

R70 160 film

C36 6.8 25V

R69 15K film

CR13

(2) 1N4152

R72 620 film

R73 160 film

E19 DC Vol

CR12

R71 750 film

R55 24K film

R63 5.6K film

+8V from A2A1A1-C16 E22

R60 1.5K film

-8V

CR11

R61 36K film

R57 36K film

R56 1K

Sig. Mtr. Zero

U6B

R62 1K

Sig.Str.Cal

E20 Sig.Str.Mtr- 970 ohm 0-2 mA

0-2.76V

R59 500

R58 4.3K film

VCR Audio

C30 47 10V

E21 VCR Audio 77.5 mV nom

S5B

Q4 2N4126

CR11 1N448

R37 15K

R38 8.2K

DS2 6.2 MHz

R39 22K

R41 24K film

S5A

Sound priority

R36 300

R40 560K film

Q5 2N5089

-5.2V

Q6 2N4126

DS3 6.8 MHz

R43 15K

R44 8.2K

R45 22K

R42 300

R46 560K film

R47 24K film

Q7 2N5089

R48 430

R50 430

R49 430 56

6.8

R51 56

6.2

R52 4.7K film

R53 adj. 4.7K film

-1.25V

R54 4.7K film

J2

J3

C25 .01

C26 .01

+8V

-5.2V (supply)

U6A NE5532

C29 .01

4.25V P-P Audio

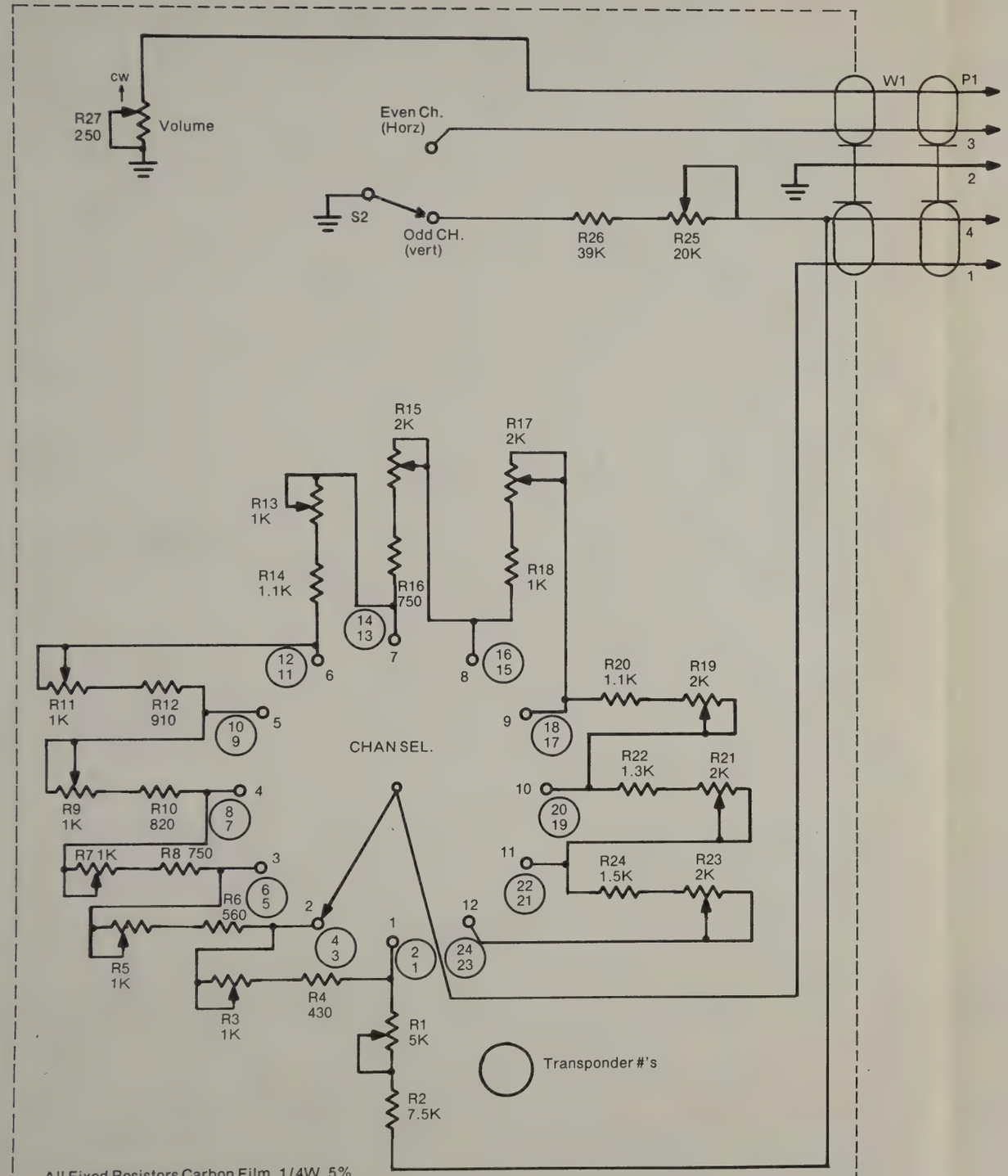
U9 LM320

C27 22 10V

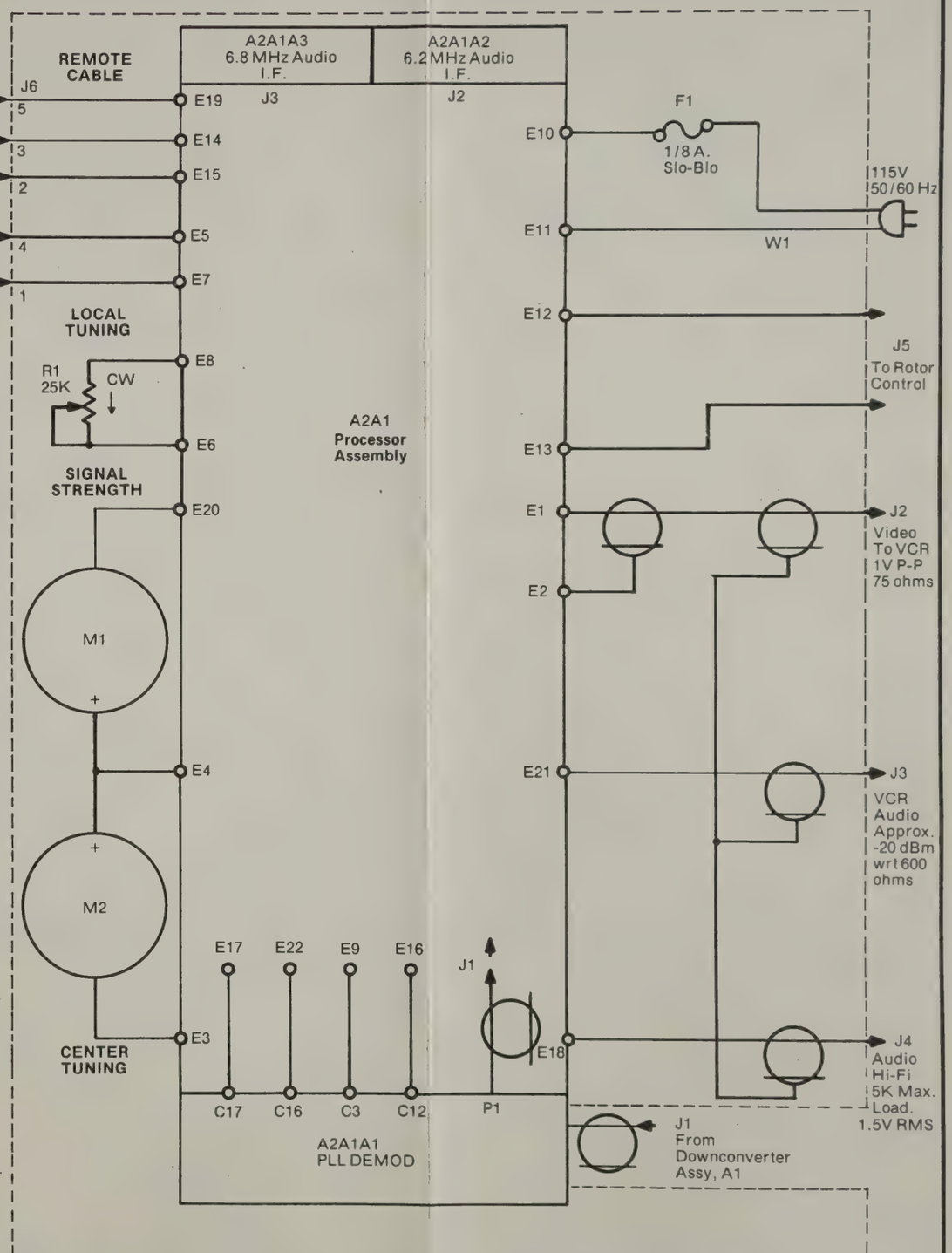
C28 2.2 16V

Unless otherwise noted - Resistors are in ohms, 5%, carbon comp, 1/4W (exc. * is 2% film)
Capacitors are in UF

Figure 16



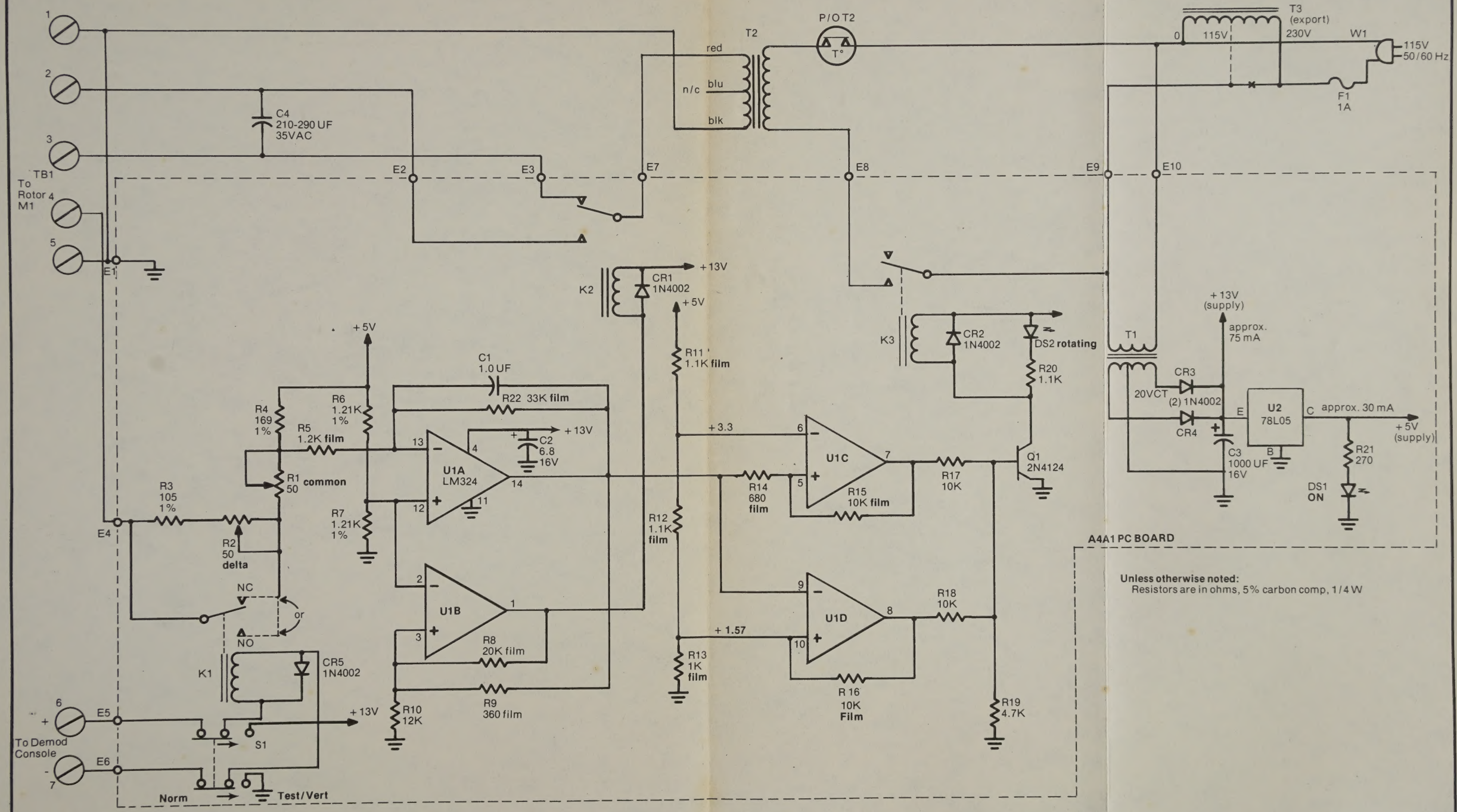

A3 REMOTE CONTROL




A2 - DEMODULATOR CONSOLE

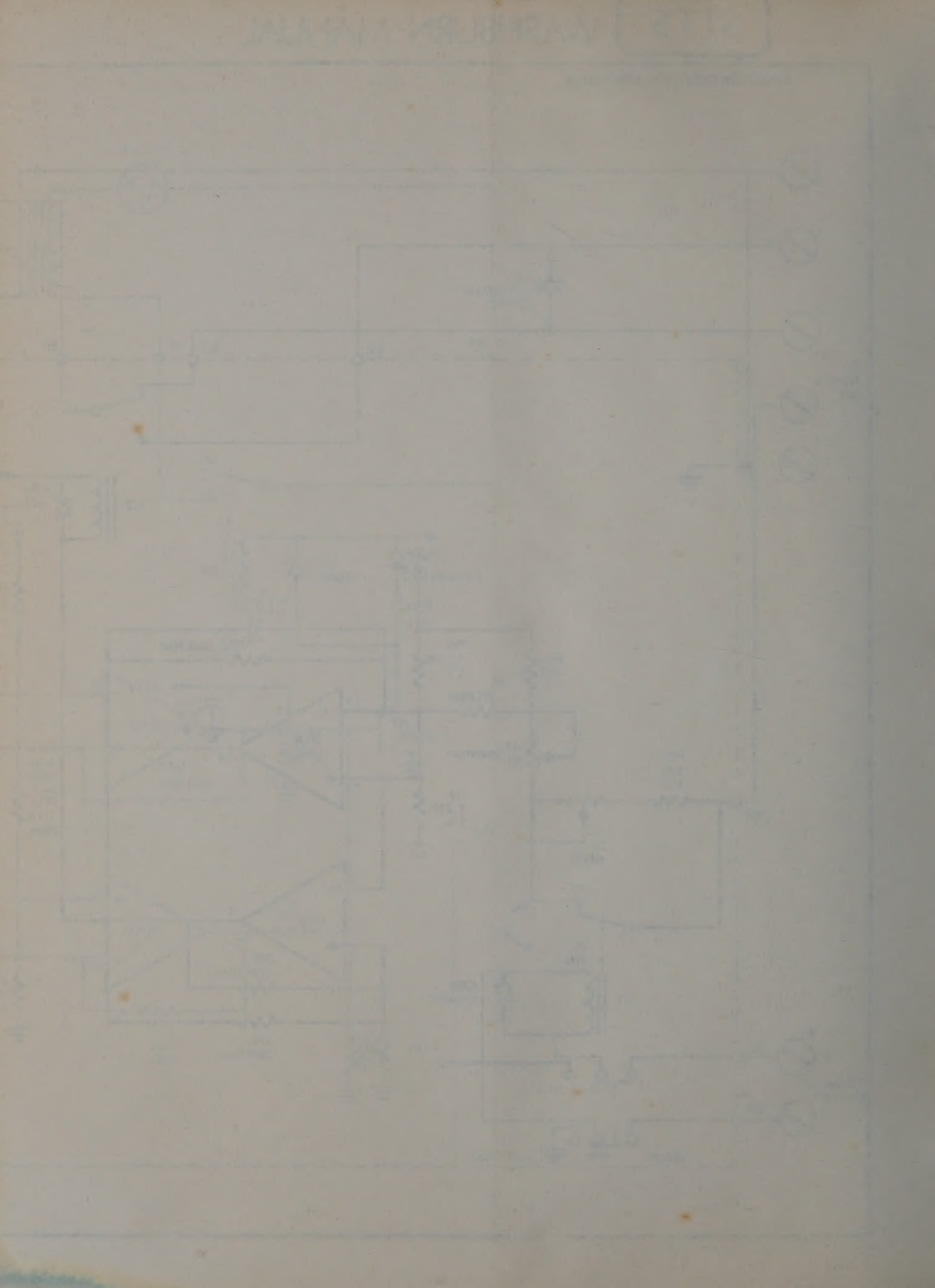
Figure 19

A4 ROTOR CONTROL ASSEMBLY




**Unless otherwise noted:**
Resistors are in ohms, 5% carbon comp, 1/4 W

Figure 25



# STT'S WASHBURN MANUAL

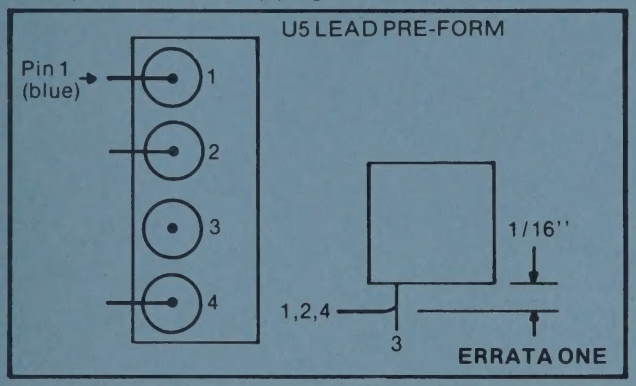


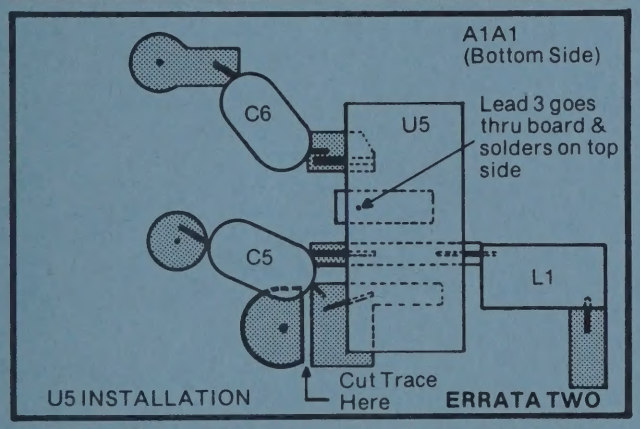
**ERRATA # ONE**

Just as this Washburn High Performance TVRO Receiver Manual was going to press we have learned that the Hewlett-Packard folks are discontinuing their 5082-9200 mixer as used for A1A1-U5. There are still some of these mixers in the distributor 'chain' but when the supply is exhausted there will be no more.

A suitable substitute is the **Mini-Circuits** TFM-2 (available from Ramsey Electronics or directly from Mini-Circuits, 2685 East 14th Street, New York, NY 11235). However several minor changes are required for substitution of the TFM-2. They are as follows (see drawings here):

**1**]Capacitor C6 changes from 1.2 pF as now stated in the parts list to 3.9 pF (Sprague 10TCC-V39).




**2**]Do **NOT** install the hairpin loops of wire at U5 as the text directs.

**3**]Cut a 1/32'' path through the copper at the location shown in **Errata Two** drawing here (trace from U4 mounting screw to U5-5; old style).

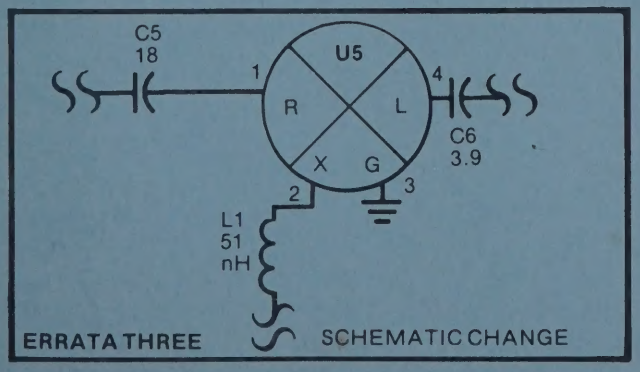
**4**]Preform the leads to the (new) Mini-Circuits TFM-5 as shown in **Errata One**.

**5**]Install L1 as shown in **Errata Three**.

**6**]Insert U5 from the **bottom** of the PC board and solder pin **3** on the **topside** ground plane (other pins are all bent over and do **not** go through the board).

**7**]Solder pins 1, 2 and 4 from the left side.

8)Install C5 and C6 as shown in **Errata Two**.




**ERRATA #2**

With this page we suggest that you go back through the enclosed Washburn Receiver Manual and make the corrections noted here:

**Page 2:** Under ''Extended Threshold'' (left hand column), find line that begins ''out compromises...'' and add the world **or** after ''IF bandwidth, ...''.

**Page 5:** In the formula appearing lower left find line that begins ''Input Noise...'' and add a **W** to the present dB at the end of the line.

**Page 6:** Under the formula for G/T° go to third line and change ''a 170 degree...'' to a **120** degree.

**Page 10:** For the formula for T° Overall, note the log-1. The **-1** should be dropped below the line.

**Page 11:** Within the boldfaced paragraph describing the Watkins-Johnson VTO, find line that begins ''CNR of 15 dB...'' and rewrite to read ''CNR of 15 dB to 12, or 10 (good quality) **to** 8.8''. ALSO - label PC drawing to read ''**TOP - A1A1**''.

**Page 15:** Under FINAL TESTS (lower left) go to last paragraph, first line and substitute word ''**signal**'' for word 'power'. ALSO - on upper right find line that begins ''critical since...'' and add ''**little can go wrong**'' between the 'and'...'if'.

**Page 16:** Under C6 the description should read ''+/- .5 pF''. Under the Vendor for part L1 the description should read ''**Standex LM-2 4-1/2T #22**''.

**Page 17:** Under U1 eliminate Engelmann Microwave who currently will make no forecast of their availability of such a part nor the pricing of such a part if and when it does become available.

**Page 20:** Right hand column, under ''1) The input noise'' drop down seven lines to line that starts ''a non-saturating...'' and substitute ''**clipping**'' for dipping.

**Page 21:** Right hand column under TESTS drop to line that begins ''varies from...'' and after word ''approximately'' add ''**100 mV to...**''.

**Page 27:** Left hand column, find line that begins ''markings.'' and add ''**of transponders**'' between 'balance' and 'should'.

**Page 28:** Locate next to last line on page and word ''fo'' should be ''**for**'' (that was our touch of ''Southern'' in respect to Robert Coleman!).

**Page 29:** Find part J1 listing. Under Vendor substitue ''**Keystone 572**'' for Switchcraft part noted.

**Page 30:** Under Parts S1,2,3,4,5 the Schadow FG should be followed by **black** (not white).

**Page 34:** Locate the circuit board layout for A2A1A2/A3. Note the eight pads along the bottom right. All Ramsey supplied circuit boards have been corrected but **if you duplicate** from this layout move the 8 pads **to the right** 1/10th'' (do **not** move anything else including traces).

**Page 35:** If the CCITT (Canadian) nomenclature/parts values are confusing, draw a line horizontally across the page just below the 7.4 MHz Center Freq. listing; all lines **below** are for CCITT subcarrier frequencies.

**Page 40:** Locate the right hand two circuit board layouts. Top board first. Note the two 'X' marks in boxes indicating the foil pattern is cut at both spots. **Add a third jumper** from the near-square foil pattern (left) after the left hand 'X' cut is made **to** the right until it connects to the vertical foil trace left after the bottom X' (cut) is made. Repeat adding a third jumper for the bottom board layout as well.

**Pages 43/44:** It was **not** intended that you would be given an ''either/or'' choice between (1) Consulting with Washburn (page 43) **or** (2) ordering circuit boards/parts (page 44). Simply Xerox one or both (yup - these pages you CAN copy!).

**Page 46:** Locate U5C. Look left and locate R15 (270). Note that as the lower lead of R15 comes down to join R16 and C25 it crosses a horizontal trace connecting to pin 11 of U5C. R15 should **NOT** connect to **that** horizontal trace. It should go **directly to** R16/C25/Pin 15 of U5C. Eliminate the connection dot showing. ALSO - go left of this spot and locate the voltage reading that says ''Approx. 1.29V''. This should read ''Approx. -1.29V''; **minus**, not positive voltage.

Remember - please keep a stamped, self addressed envelope on file for further corrections and updates.